ON

THE PALÆOZOIC

AND THEIR

ASSOCIATED ROCKS

OF THE

THÜRINGERWALD AND THE HARZ.

BY

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AND

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On the Palæozoic *and their Associated* Rocks *of the* Thüringerwald *and the* Harz.

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PART I.

Introduction.—The advice given by a distinguished French savant many years ago to one of us, then full of zeal to discover geological phænomena unknown to his contemporaries, was,—"Examine the travelling map of the region in which you may happen to be, and wherever you see a tract void of all post roads, go thither, and you will infallibly meet with something new to science."

This suggestion has since been our guiding rule in many excursions, including several visits to the insulated mountain-tracts of the Thüringerwald and the Harz, which in bygone years were traversed by no post roads, and which in these days of rapid locomotion are avoided by all railroads.

When Sedgwick and Murchison first looked at the Thüringerwald frontier in 1839, that chain had little attracted the attention of geologists, with the exception of Von Hoff of Gotha, who had then described the physical features of its northern half, determining several altitudes, and giving a general *aperçu* of its crystalline and

eruptive rocks. It was then that the English geologists compared the southern limb of the chain with the masses of older rocks in the Rhenish provinces and those with of the Harz, and also endeavoured to indicate the German districts to which the terminology used to distinguish the ancient British sedi[illegible]nations might be applied. As that survey, the result of w[illegible]embodied in the 'Transactions of the Geological Society,' w[illegible]ade in one long summer only, and as at that time there were few local collectors of palæozoic fossils, it was not to be expected that the authors could offer more than a broad and suggestive outline.

In the sixteen years which have elapsed since that memoir was published, the Rhenish provinces have been sedulously examined by various able geologists and palæontologists, who have accurately defined the limits of the sub-formations of each group, and have shown that, if the distribution of animal life be the guide, there are no true Silurian rocks in the Rhenish provinces—provided the adjacent slaty masses of the Ardennes should not prove to be such. The great mass of the Rhenish fossils pertain unquestionably to the Devonian rocks, and constitute, as we have lately stated, a triple group, of which the Spirifers and stones and slates form the base, the Eifel limestones the centre, and the Cypridina and Clymenia schists and limestones the upper band *.

This group is clearly followed by the Lower Carboniferous rocks properly so called, because they contain true mountain limestone fossils, and also certain plants; the order of succession being admirably exposed on the northern edges of the hills which flank the lower country of Westphalia. Much of this lower carboniferous group is mineralogically identical with the culm series of Devonshire, whilst the uppermost band of it, the 'flœtz-leerer sandstone,' is the equivalent of the British millstone grit, as first shown in the memoir above cited †. We may here refer to the original General Section (fig. 1, pl. 23, Geol. Trans. 2 ser. vol. vi.) made by us when we first examined the Rhenish rocks in 1839—which shows how truly the physical order is what it was then represented to be.

Such is the succession in the Rhenish provinces, and of this we have elsewhere given a condensed description and synopsis ‡ as prepared from our own observation and that of competent authorities, who have corrected the details and amplified the original comparison of the rocks with British types.

When the first comparative survey of the older rocks of Germany was made, no one had developed in any part of that vast region a true Silurian series; but in the interval M. Barrande has had the high merit of showing the existence in Bohemia of a perfect basin of all those rocks which he terms Silurian, *i.e.* from an unfossiliferous base through great masses of sediment representing the Lower and Upper Silurian divisions.

Now, each of the two tracts which are brought under considera-

* 'Siluria' (1854), p. 367, &c.
† Trans. Geol. Soc. 2 ser. vol. vi. p. 228, 229.
‡ 'Siluria,' p. 382.

tion exhibits, as we shall indicate, some members of the Silurian of Bohemia and of the Devonian and Lower Carboniferous of the Rhenish provinces; the two latter groups being unknown in Bohemia. If this is what might be expected in tracts lying in an intermediate position between the go[illegible]s of the Rhine and the country of Prague, we shall have to point out distinctions in the details of succession which it is importa[illegible]note, as occurring in Thuringia on the one hand and in the Harz upon the other.

Attention will also be pointedly directed to those younger palæozoic deposits which overlie the small patches of coal known in Central Germany, and which one of us has described in other works as the "Permian Group." Indicating the great break above all the series from a primordial base up to the Lower Carboniferous inclusive (the wide-spread "Grauwacke" of old geologists) as separating all such deposits from the overlying and youngest palæozoic strata, it will be shown by what agency the original direction of the lower portion whose strike is universally from N.E. to S.W. has been changed to N.W. and S.E. as respects the geographical outline. Brief and general as the sketch is, it will point out the agreements and discrepancies of these German rocks as compared with each other, and refer them to types which are well known to British geologists.

Whilst the sectional woodcuts will explain some of these varied relations, a Tabular View (see p. 448) of the general order of the Palæozoic rocks of Germany with the lower secondary rocks which immediately overlie them is appended to the memoir, and in that table we have paralleled the foreign rocks with their English analogues.

THE THÜRINGERWALD.—In the work called 'Siluria,' recently published, we have given a succinct view of the succession of the strata in the Thüringerwald, as an addition to the first general sketch of that tract which appeared many years ago in the 'Transactions of the Geological Society.' In that work we have cited the map of Richter of Saalfeld* as most illustrative of the southern portion of this mountainous tract, and have particularly adverted to the map of Credner of Gotha as developing with great accuracy the features of the northern Thüringerwald. M. Credner having now completed his map of the whole chain, we had the advantage of consulting it on our last excursion. When collated with a general view by the same author printed in the 'Transactions of the Academy of Erfurt †,' that map gives so clear a view of the range in question, that the present communication might at first sight seem superfluous. But, in truth, it is still important to make our foreign contemporaries understand the true application of our insular terms in classifying their older rocks; whilst our countrymen will, we hope, be made to apprehend more clearly the manner in which the *physical divisional lines* between the respective palæozoic formations of Germany differ from those which have been observed in England.

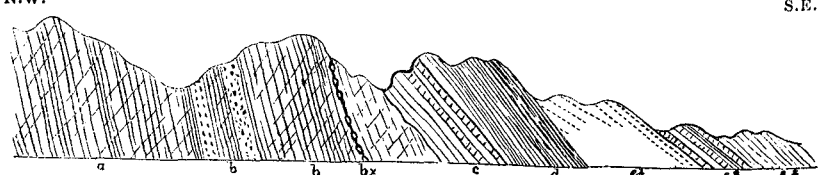
Viewed in a geographical sense, the Thüringerwald is a mountain-

* Zeitschr. Deutsch. Geol. Gesell. Berlin, vol. iii. p. 536. pl. 20.
† Denkschrift der Königl. Ak. gemeinnütziger Wissensch. zu Erfurt, 1854.

ous wooded mass, the culminating points of which never exceed 3500 English feet above the sea, and whose main direction is from N.W. to S.E. Its length from the environs of Eisenach on the N.W. to those of Kronach on the S.E. is upwards of sixty miles, and swelling in width from a narrow apex on the N.W. it attains a maximum width of about twenty miles in its S.E. portion.

The south-eastern half of this tract is essentially distinct from the north-western; the first or wide part being made up of very ancient sedimentary strata, the second of crystalline rocks chiefly eruptive and here and there of metamorphic character; whilst the whole is surrounded by a girdle of Permian rocks, followed by lower mesozoic deposits which delineate the dominant direction of the mountains which they subtend.

Fig. 1.—*Diagram showing the General Succession of the Palæozoic Rocks in the Thüringerwald.* Horizontal distance about 12 miles.



Lower Grauwacke or Cambrian, and Silurian.—The most ancient rocks, as seen in the S. Thüringerwald, consist of greenish talcose schists, traversed by white quartz veins, and of ferruginous and purple sandstone, the latter much resembling certain rocks of the Longmynd in Shropshire. When examined in detail, these rocks (marked *a* in the general diagram, fig. 1) exhibit towards the base quartz rock and dark slaty schist, the latter containing aluminiferous schist. These form the lowest courses, as seen in several undulations; the upper and chief part being the greenish slaty rocks above mentioned, and in which whetstones occur. In these rocks ("grüne grauwacke" of Richter, or "Cambrian" of the British Geological Survey), which have all been affected by a slaty cleavage, no other organic remains except Fucoids (*Phycodes circinatus*) have been found.

These fundamental rocks (*a*), exhibited in masses of great dimensions, and attaining, in the Oberland of Meiningen, elevations of upwards of 3000 feet above the sea, are covered conformably by the deposits which M. Richter termed grey grauwacke, an extensive and diversified group (*b*) of slate and sandstone with some courses of aluminiferous schist (*graue grauwacke, dach-schiefer, griffel-schiefer*, &c.), the whole of which is referable through its fossils to the Lower Silurian rocks. The section, fig. 1, merely represents the general succession. But from the observations of M. Richter, we believe that this fossiliferous Lower Silurian consists in its inferior portion of roofing-slates and coarse grits (almost conglomerates), subordinate to

which are several beds with *Nereites, Orthis* resembling *O. grandis*, Sil. Syst., and *Beyrichia complicata*, whilst the schists contain many *Graptolites*. Whether there be Fucoids and Annelids in the lowest of these strata, or Trilobites, including *Ogygiæ*, of the type of *O.* (*Asaphus*) *Buchii, Orthidæ*, and *Graptolites* in the central and superior portions of the same, we have elsewhere* enumerated a sufficient number of fossils to leave no doubt of the true Silurian age of these grey-coloured slaty rocks, as recognized by M. Richter. In abundance of Graptolites and Annelids the Lower Silurians of the Thüringerwald bear, indeed, a most striking resemblance to the strata of the same age in the south of Scotland, which like them repose on rocks wherein no remains of animal life have yet been detected.

It is well worthy of note that several species of the *Graptolites* of the Thüringerwald and adjacent parts of Saxony are identical with British and particularly with Scottish types, and are also known in Bohemia, Scandinavia, North America, &c. The larger *Nereites* and the *Protovirgularia dichotoma* of this tract are also identical with Scottish types collected by Harkness and compared by Salter.

The impure limestone (b^+) lies in the upper portion of the series, and in it and the associated shale are found *Graptolites priodon* (*Ludensis*, Sil. Syst.) and other Graptolites, with *Orthoceras Bohemicum*? (*O. Ibex*), *O. styloideum*, and a Crinoid resembling *Crotalocrinus*. M. Barrande had suggested that this band might represent the base of the Upper Silurian of Bohemia or the lower part of the Wenlock; but, judging from any fossils we saw, we are unable to confirm this idea. For, whilst in Bohemia the Graptolite shales clearly overlie the mass of the Lower Silurian rocks, we know that in Britain the very same species of Graptolites descend into the inferior division of the Llandeilo formation†.

All these rocks have a strike from N.E. to S.W., which is therefore at right angles to the geographical axis or watershed of the chain, whilst the prevalent dip is to the S.E. It must here, however, be noted, that slaty cleavage planes are in general so prevalent, their dip being persistently to the N.W., that true observations on

* 'Siluria,' p. 352, 353.

† Whilst this memoir was passing through the press I received a letter from M. Richter, of Saalfeld, in which he states, that in the Lower Silurian slates there occur *Nereites, Myrianites, Lophoctenium, Orthis, Orbicula, Cladograpsus, Phytopsis, Palmophycus, Buthotrephis*. In the conglomerates which alternate with the Nereite beds are found *Beyrichia complicata*, Salt.; some undetermined Trilobites, *Orthis redux*, Barr., *O. testudinaria*, Dalm., *O. alternata*, ? 'Sil. Syst.,' *O. lata*, ib., *Leptæna sericea*, ib., *Pentamerus oblongus* and *P. globosus*, ib., *Fenestella subantiqua*, D'Orb., *Petraia subduplicata*, M'Coy, *Sarcinula organum* ?, Linn., *Nidulites favus* ?, Salt., and a Coral which was sent by me to my friend Mr. Lonsdale, who pronounced it to be a *Pleurodictyum*. M. Richter has since described it as a species distinct from the *P. problematicum* of the Devonian rocks, and has named it *P. Lonsdalei*. M. Richter confirms my view of the absence of all Devonian rocks except the Upper or Cypridina group, which he divides into two stages. As he has not observed any union between the Upper Devonian and the lowest Carboniferous strata, it is probable that there is a break, and that the Productus limestone and Kieselschiefer (which are present at Hof) being absent, the Upper Devonian of Saalfeld is at once succeeded by the equivalent of the Millstone grit—or "flœtz-leerer Sandstein" of the Germans.—R. I. MURCHISON, Sept. 15, 1855.

the real bedding are made with difficulty. Another and a still greater impediment to a clear examination of the lie of the strata consists in the dense covering of wood and the rare occurrence of rocks and open ravines. Even in places where the strata are visible, the geologist who is not versed in the lines of cleavage may easily assume that the latter are laminæ of deposit. In truth, the native geologists who have treated of these rocks were so deceived, that they were led thereby to represent in their earlier works that which would amount to a total inversion of all the mountain masses by a dip to the N.W., when in reality the strata (though subject to great undulations not represented in our general section) assume a prevalent inclination to the S.E.

Upper Devonian.—The "younger grauwacke" of this region (so styled by both Credner and Richter) consists of a union of the sub-groups which we term Upper Devonian and Lower Carboniferous. Constituting apparently one physical mass, these formations cover transgressively the Lower Silurian rocks, or abut abruptly against them (see fig. 1, *c* and *d*). In travelling across these strata, as exposed in the southernmost portion of the chain, *i. e.* between Koppelsdorf and Steinach, we found unequivocal Upper Devonian fossils in the higher strata, associated with limestones, and carboniferous plants of large size in the younger and more arenaceous deposits.

In that district, however, the disturbances have been so great (particularly along the banks of the river Steinach), and the strata are there so completely inverted, that M. Engelhardt very naturally represented as Lower Silurian those limestones which from their fossils we now know to be Devonian, and considered the rocks which are truly of that age to be Upper Silurian.

Passing, however, from that convulsed district, the real relations of the Devonian rocks of the Thüringerwald are best seen in the environs of Saalfeld, and particularly to the S.E. of that town, where they abut against the Silurian in the gorge of the river Saal. There, as in all the adjacent parts of Saxony extending by Schleitz to Plauen and Hof, there are no equivalents of the Upper Silurian or of the Lower or Middle Devonian. In the absence of the Spirifer-sandstone of the Rhine, and of the limestone of the Eifel, or their equivalents, the limestone, which we are about to describe, and which rests at once on the slaty Lower Silurian, is truly Upper Devonian.

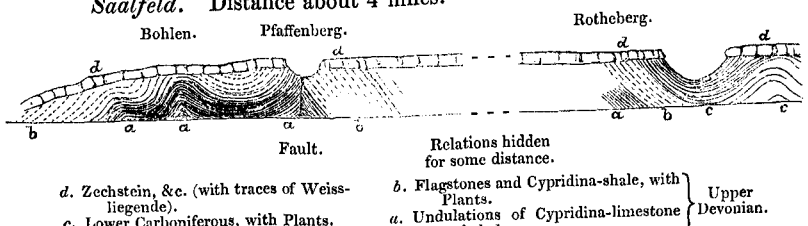
In the undulating region to the east, which has been mapped by Naumann and his associates and described by Geinitz, the Upper Devonian is much swollen out and distinguished by interpolated sheets of igneous rock, the Schaalstein of the Rhine. On this occasion we forbear to enter into a detailed account of such rocks, and will now only speak of the Upper Devonian of Saalfeld, as seen in the cliffs at Bohlen, and the relation of the deposit to the younger strata of the Rotheberg, which we consider to be Lower Carboniferous. (See fig. 2.)

On quitting the grey Silurian, or truly "*grauwacke*" region of Saalfeld, and the tracts to the west and south of that town, and in

proceeding to the east, the traveller suddenly finds himself at the foot of lofty calcareous cliffs of dark-reddish limestone and calcareous schist, with many nodules. Judging from the colour and external aspect of the rocks alone, the geologist sees, that in moving to the east he has left behind him everything to which the word 'grauwacke' can be correctly applied, and has entered among stony masses, which, whether they be red, brown, ferruginous, or dullish and greenish white, are lithologically dissimilar to what he has traversed in the loftier hills of the forest. Overlying unconformably certain dark-coloured Silurian schists, the chief strata are calcareous beds, quarried as large flagstones, whose surfaces are distinguished by a multitude of greyish calcareous concretions, in a matrix of dark red shale.

These strata (fig. 2, *a*) are folded over in rapid undulations in the course of half a mile on the right bank of the river, and are fairly surmounted by thin-bedded, light greenish-grey, brown, and black schists, and shivery siliceous flags (*b*).

Fig. 2.—*Section showing the relations of the Upper Devonian and the Lower Carboniferous Rocks in the Gorge of the Saal, near Saalfeld.* Distance about 4 miles.



The inferior limestones and calcareous schists contain many fossils, which have never been referred to any type except that which the geologists of the Rhine, the brothers Sandberger and F. Roemer, class as Upper Devonian; whilst the concretionary schists and limestones in which they occur are to a great extent lithologically similar to the rocks of the western part of the Rhenish provinces, locally called Kramenzel-stein, or ant-stone*.

It may here be mentioned, that not one true carboniferous fossil (no large *Productus* for example) has been detected in this formation, which here has certainly a thickness of several hundred feet. On the other hand, all the typical forms are Devonian; viz. *Phacops*, three species; *Clymenia*, ten species; *Orthoceras*, thirteen species; *Goniatites*, eight species; and *Cypridinæ* in abundance, including the *C. serrato-striata* of the Rhine and Devonshire. The *Cypridina serrato-striata*, which so pre-eminently characterizes the Upper Devonian zone in the Rhenish provinces and the districts of Franconia,

* The Devonian fossils of Saalfeld, according to Richter, are—Cypridina, 2 sp.; Phacops, 2 sp.; Asaphus?; Bellerophon, 1 sp.; Orthoceratites, 13 sp.; Lituites, 2 sp.; Nautilus, 1 sp.; Clymenia, 10 sp.; Goniatites, 8 sp.; Euomphalus, 1 sp.; Cyathocrinus, 1 sp.; Actinocrinus, 1 sp.; and about 12 species of Cardinia, Terebratula, Avicula, &c. Many of these fossils are identical with those described by Count Münster, from the north flank of the Fichtelgebirge.

adjacent to the Thüringerwald, and, as we shall presently see, occurs in the Harz, is also here so abundant, that the name "Cypridina-schiefer" is just as applicable at Saalfeld as in the above-mentioned tracts.

A few small plants have been discovered in these schists; but it is specially as we ascend into the upper division of this formation (fig. 2, *b*) that fossil plants increase rapidly in number, particularly in certain hard, thin, siliceous courses of purplish and greenish sandstone. It is in this rock that M. Richter has found so many of the peculiar plants which, under the examination of Prof. Unger of Gratz, are stated to belong almost entirely to new genera and species. Of these, thirty-three species are enumerated as belonging to *Calamariæ*, *Filices*, *Selagines*, and two species to *Zamiæ* and *Coniferæ*. M. Unger believes that he has discovered in some of these plants a structure which indicates that they are prototypes of new genera, and possibly of new families, and others which indicate transitions between families already known*.

Following the strata in ascending order on the left bank of the Saal, and after passing over soft schists (the relations of which are obscured), we come to deep undulations, in which rocks of a mineral character quite unknown in any of the inferior deposits are exposed. These beds (*c*), which are well seen in a ravine around which the road winds opposite Teuschnitz, are highly ferruginous, brownish, micaceous sandstones, which range from the Rotheberg to the locality where we saw the plants. The surfaces of these beds are covered by many large plants, distinct from those of the inferior strata. Among them are *Calamites transitionis*, *Rothebergia* (*Megaphyllum*) *Hollobeni*, and many others. Such lower carboniferous strata occur also in Saxony, particularly at Hainichen Ebersdorf, where coal is worked in them, and Prof. Geinitz has described the numerous plants they contain as being composed of *Calamitaceæ*, 3 species; *Filices*, 6; *Lycopodiaceæ*, 10; *Stigmaria* and *Sigillaria*, 2; and seeds of plants, 2 species. According to Geinitz, one only of these twenty-three species is found in the newer and overlying coal fields of Saxony.

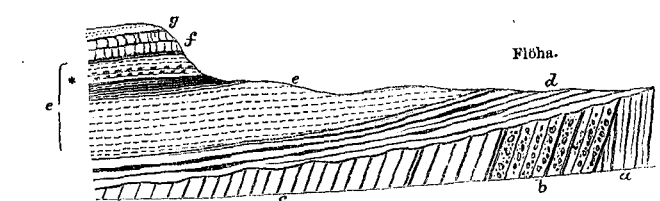
In short, all the plants last enumerated are now recognized by Geinitz as belonging to the lower coal; whilst those associated with the Cypridina-schists, or Upper Devonian, are, as Richter and Unger state, peculiar to that band. Here, then, if a transition should be traced from one set of beds to the other, we see a considerable distinction between the plants of the one and the other group. And, although the decisive test of any intermediate representative of the Mountain or Carboniferous Limestone is here wanting, it was long ago proved by Prof. Sedgwick and one of us, that in the adjacent country of Hof, in Bavaria, a Devonian limestone, which we have since ascertained to be precisely like that of Saalfeld, from its myriads of *Cypridinæ*, is at once surmounted by schists, sandstones, and a limestone with several species of *Producti* which are common in the Carboniferous Limestone of Britain.

* See 'Zur Flora des Cypridinen-schiefers,' von Prof. F. Unger, Berichte Akad. Wiss. Wien, Bd. 12. p. 595. The complete work is about to be published by Richter and Unger.

It must here be stated, though it forms no part of the Thüringerwald, that all the lower and undulating region between the eastern flank of that chain and the Erzgebirge is occupied either by Lower Silurian rocks as above defined, or by bands of Upper Devonian and Lower Carboniferous strata. The whole of these rocks, in contrast to the Thüringerwald, have preserved, to a great extent, a geographical direction from N.E. to S.W., in unison with their original strike. Associated with the Devonian and younger rocks of this large tract, the southern limits of which extend up to the Fichtelgebirge (their northern edges being buried under the Permian rocks of Gera and Pösneck), there is, as before said, a great interlamination of contemporaneous volcanic grit, or ash, which in many parts assumes precisely the form of the "Schaalstein" of the Rhine. Besides these, certain eruptive rocks, of posterior date, protrude here and there; these are quite distinct from the contemporaneous volcanic dejections above mentioned, and the deposits affected by them have been thrown into countless breaks and rapid undulations. In this way, black Lower Silurian slates, with *Graptolites* and *Orthidæ*, occur in juxtaposition to Upper Devonian. The latter, often expanded to considerable dimensions by the alternation of contemporaneous volcanic materials, and yet containing the same *Cypridinæ* and other fossils as at Saalfeld, are, in some localities, surmounted by sandstones, flinty slate, and limestone, charged with the unequivocal fossils of the Carboniferous Limestone; thus removing all doubt respecting the true order.

With this carboniferous zone terminate, in ascending order, all the formations, which the Germans have hitherto designated under the omnivorous word "Grauwacke;" *i.e.*, from the azoic base of the sedimentary rocks to the Millstone Grit inclusive. For all these rocks constitute, in a physical sense, one great mass in Germany, and, to a great extent, in France. They are entirely dismembered from all overlying formations, including the great or Upper Coal-fields of England,—a feature to which we shall again have occasion to allude in speaking of the Harz mountains, and on which we shall offer a general observation or two in our conclusions.

Fig. 3.—*Diagram exhibiting the general relations of the Palæozoic Rocks in Saxony.* (Chiefly from Naumann.)



g. Sandschiefer.
f. Zechstein. Kupfer-schiefer, &c. } Permian.
e. Rothe-todte-liegende. } Permian.
* Plant-beds.

d. Upper Carboniferous (Flöha and Zwickau). } Geinitz.
c. Lower Carboniferous (Hainichen-Ebersdorf). } Geinitz.
b. Devonian.
a. Silurian.

In the meantime, attention is directed to section fig. 3, p. 417, which explains how, in the adjacent kingdom of Saxony, the three great inferior groups, viz. Silurian, Devonian, and Lower Carboniferous, are unconformably surmounted by the upper coal, and how the latter is followed by the Permian rocks. The clear physical distinction between the Lower and Upper Carboniferous, which was pointed out by Naumann, has since been confirmed by the palæontological labours of Prof. Geinitz.

Coal deposits (Kohlen-Gebirge).—In the Thüringerwald and the adjacent parts of Saxony and Bavaria, as in Bohemia, the strata from which coal is extracted overlie in transgressive positions all the other ancient rocks. (See fig. 3). In the Thüringerwald, and those places where we are acquainted with them, such coal deposits consist of lightish grey schists, or shale, and sandstones, in some of which there are numerous impressions of fossil plants. In none of these tracts has any indication yet been discovered of included animal remains, to prove that these accumulations were formed under the sea, or in marine estuaries like those of the antecedent Lower Carboniferous rocks, from which they are so sharply separated. The remains of vegetables with which they are filled have, it is true, the general *facies* of the rich carboniferous flora; but under a critical eye, the one set of plants is found to be distinct from the other in some genera, and in nearly all the species. For this fact, particularly as relates to Saxony, we are, as already mentioned, indebted to the recent researches of Prof. Geinitz *.

Whilst on this point, we can scarcely avoid reminding our countrymen, that as yet no geologist has endeavoured to ascertain whether or not there be the same marked distinctions between the floras of the Lower Carboniferous of Scotland and the overlying great coal-fields of England, as that which has been worked out in Saxony.

In the Thüringerwald, as in most parts of Central Germany, some geologists would indeed prefer to class these grey and dark coaly deposits with the red conglomerates and sandstones (Rothe-todte-liegende) which overlie them. But, guided by the analogies of Britain and North America, where the coal deposits resting upon the Lower Carboniferous rocks are symmetrically united over enormous areas, and unquestionably belong, by their remains, to the same great epoch, we adhere to the belief, that most of these small coal deposits, broken off as they are from the superior red strata of Permian age, are still to be classed with the carboniferous group. By this observation, however, it is not to be inferred that we are not quite aware of the existence of certain thin courses of coaly matter, associated with the Rothe-todte-liegende itself in parts of Germany.

Desirous of satisfying ourselves more perfectly on this point, and intending to revisit tracts where light may be thrown on the question, we must remark that, as far as our knowledge goes, the chief German coal distinctly underlies, and is never intermixed with, the Rothe-todte-liegende, or bottom rock of the Permian æra. Though

* Darstellung der Flora des Hainichen-Ebersdorfer und des Flöhaer Kohlenbassins. Fol. Leipzig (Hirzel), 1854.

Credner leaves it to be inferred (in some of the sections accompanying his map) that this coal of the Thüringerwald is conformable to the overlying red conglomerate and sandstone, there are tracts, even in this region, where the two rocks are unconformable; and Gutbier has shown that this is decisively so in the environs of Zwickau.

At Manebach, near Ilmenau, several thin seams of coal, the chief of which is about three feet thick, are extracted by horizontal galleries, on the east side of a deep valley, from beds of shale overlying gritty sandstone of dark and light colour, the last very thick-bedded, and the strata dipping N.E. about 13°. These are traversed and covered by rocks of igneous origin. In several spots the intrusive rock is a red quartziferous porphyry; at another place, about a quarter of a mile distant, the coaly strata are cut off by a granite or granitello, which, if it does not exhibit passages into porphyry, is at all events of very varied composition, even in the space of a few yards. At a third point the intrusive rock is a black porphyry (melaphyre).

These rocks have all been erupted through the coaly sediments, and have in great part overflowed them; for the red porphyry in particular forms the mass of the hill capping the coal strata.

In traversing the northern Thüringerwald on two parallels, we observed that the coal strata hardly rose up to points of any considerable elevation on the sides of the valleys; but usually outcropped from beneath those red rocks (the Rothe-todte-liegende) and the associated porphyries to which we shall presently allude.

At the southern extremity of the chain, north of Kronach, we had the clearest evidences of the coal being worked entirely from beneath accumulations of the Rothe-todte-liegende, of a thickness probably of 2000 feet, which, being inclined at high angles in a great recess in the older rocks, permits the coal strata (which are only visible in partial outcrops) to be worked by shafts of moderate depth.

In visiting two of the spots where coal is extracted, we could not satisfy ourselves as to the true character of the strata which there form the base of the coal deposit. According to M. Büttner of Kronach, one of the superintendents of these works, the lowest carbonaceous rock, abutting against the "Younger Grauwacke" (there Upper Devonian and Lower Carboniferous rocks), is a jaspidean claystone, which is followed upwards by a sort of conglomerate containing fragments of older porphyry. The immediate support, however, of the coal-bearing strata is a whitish coarse grit, not unlike one of the beds near Ilmenau. Associated with the coal, and forming its roof, there is a finely laminated indurated shale, in parts resembling the "black bat," so well known in Staffordshire and other English coal fields.

At Stockheim and Neuhaus, which we visited, and where the coal is raised in a shaft about 250 feet deep, the chief bed of coal was estimated at about 12 or 14 feet in thickness. The coal strata are much disturbed, and inclined, at angles varying from 80° to 25°, 60° to 50°, and thence to 25° near the surface, where they underlie the Rothe-todte-liegende or red rock. It is probable that part of this thickness may be in great measure due to an oblique section of

the chief carbonaceous band. Again, we observed that by far the larger part of the mineral which was brought up in the shaft was not true coal, but scaly bituminous shale. The coal being carefully picked up in pieces which seldom exceeded the fist in size, and usually much smaller, was packed in neat new small barrels of wood, as carefully as herrings are stowed away at a fishing station,—so great is the value set upon the combustible, when transported from its natural position to the interior of Bavaria. At Neuhaus, where the pits are sunk in a deep depression from beneath an escarpment in the Rothe-todte-liegende, the coal is extracted in larger and cleaner fragments.

On the whole, it was manifest that the coal strata around the Thuringian chain, wherever we examined them, had been broken through and disturbed by those igneous rocks which played a still more important part in the older portion of the following or Permian æra, the strata of which are so enormously developed in and around these mountains, and especially in their northern portion.

Permian Deposits of the Thüringerwald.

Rothe-todte-liegende.—A great contrast is visible between the grey and dark coal strata of which we have taken leave and the overlying red deposits, which, under the name of Rothe-todte-liegende, occupy so large a part of this region. (See fig. 4, p. 424.). Judging from their fine lamination and their imbedded fossil plants, the former have unquestionably resulted from tranquil deposition under water, probably fluviatile or lacustrine; whilst the latter, which we now proceed to consider, have been formed in a period of turbulence, accompanied by the extrusion of much igneous matter.

The great red formation named the Rothe-todte-liegende has been described by so many German authors, that it is unnecessary to dilate upon its structure. We would, however, remark, that, much as we have examined the deposit in different parts of Germany, we know of no tract in which it is of larger vertical dimensions or is so exhibited in mountainous masses and on the sides of deep ravines as in the Thüringerwald.

The chief development of the deposit is seen in the northern half of the chain. It is singularly well displayed, for example, both in quarries and on the sides of the high road leading to Frankfort, immediately above Eisenach, and on the flanks of the hill on which the convent and castle of Wartzburg stand, once the residence of Luther.

It is indeed to be studied in so many localities, whether on the flanks of the northern ridge or in its interior, where it is associated with porphyries, that M. Credner's map and the excellent roads both longitudinal and transversal will lead every traveller to numerous exhibitions of the rock.

Though argillaceous and thick-bedded sandstones of dark red brick colour are chiefly exposed at the base of some of the natural sections where the deposit overlies the coal strata, and whilst such finely levigated red substance forms the matrix of many of the

coarser beds, the dominant features of the formation, particularly of its middle and upper members, are the so-called conglomerates. These great bands, often of vast thickness, ought, strictly speaking, to be termed breccias, particularly near Eisenach. For, whatever be the included material, whether quartz rock, mica schist, old porphyry, granite, or greywacke slate, the fragments are usually angular; none of them presenting the aspect of having been rolled on a beach or rounded by the action of the waves. However these angular or subangular pieces were accumulated, the impression left on the mind of the observer is, that they were got together in a very rapid and tumultuous manner.

The movements, however, by which they were aggregated were clearly suspended and repeated many times; the intervals of quiescence allowing of those deposits of finely triturated red sand and mud which alternate with the coarse and subangular breccia. In the granitic breccia under the Wartzburg, it is curious to remark (as pointed out to us by Professor Senft of Eisenach), that the included granite fragments in one of the several courses which we observed to alternate with beds of sand and shale have been derived from a rock no longer visible in the chain of the Thüringerwald, but which was doubtless a mass once near at hand—probably just beneath the very breccia that has been made out of it. It is a granite containing pericline and black mica.

These angular breccias and conglomerates, with their associated sandstones, are of gigantic dimensions, and have been bored into in fruitless searches after coal to a depth of about 2500 English feet! Their chief mineral characteristic is their intimate association with huge masses of porphyry, some of which have manifestly been emitted coincidently with the formation of the breccias. So intimate, indeed, is the association, that here, as in many tracts of Germany, it is occasionally most difficult to disentangle that which may be termed a true eruptive rock from bands of breccia in which other fragments of altered schistose and the older sedimentary rocks are mixed up. This is peculiarly the case where the porphyritic matter has overflowed and has been extended horizontally.

An examination of this chain proves, that the northern Thüringerwald has been penetrated at almost countless points by porphyries of various characters, and of which M. Credner distinguishes about six varieties in the red or quartziferous porphyry alone. True melaphyre (or the so-called black porphyry) is also abundant.

It would appear that rocks of igneous origin have penetrated this chain from a very early period. Thus, in the Lower Silurian slates we meet with greenstone, granite, and an ancient red porphyry, the last-mentioned being in fact the rock whose fragments are found in the Coal-measures and Rothe-todte-liegende. These old eruptive masses are said by M. Credner to be limited to the Silurian and not to enter into the Devonian strata,—a point on which we have not yet satisfied ourselves.

Hypersthene rocks are seen to rise through the Upper Carboniferous layers and to have greatly altered them: but it is only on ascending

to the Rothe-todte-liegende that we are surrounded on all sides with porphyry, and as this period of turbulence was followed by one of beach action and quiescent marine deposits, to which we shall presently advert, it is quite manifest, that all the breccias and coarse conglomerates, however composed of mixed materials, were formed during a period of igneous action, perhaps more intense than any to which an appeal can be made in the history of other German formations. In fact, it was in this, the earlier part of the Permian æra, that those grand eruptions took place from N.E. to S.W. which obscured the ancient physical direction of the rocky and slaty masses that trend from N.E. to S.W., and determined the axis or watershed to be at right angles to the original outline of the ridges.

As we shall have to speak of a similar phænomenon in the Harz, we reserve for awhile our inferences concerning the condition of the earth's surface during the tumultuous period of the earlier of the Permian deposits, when such vast physical changes occurred.

In the meantime we may indeed truly say, with M. Credner, that the northern portion of the Thüringerwald is essentially a porphyritic chain; since nearly all its highest central summits, from the Kahle Berg and the Inselsberg, the latter 3096 English feet, to the Schnee Kopf or highest point, about 3300 English feet above the sea, consist of red porphyries, which ranging from N.E. to S.W. constitute what is locally termed the Rennsteig or central ridge, which determines the axis or watershed to which all the rock-masses of the chain have in a geographical sense been rendered subordinate.

No organic remains have been found in the Rothe-todte-liegende of the Thüringerwald, as might indeed be expected from the mineral structure and condition of the rocks, except certain hard silicified stems of fossil plants, *Psaroniæ*, &c.

In the environs of Zwickau, Chemnitz, Dresden, &c., however, where very finely laminated claystones are intercalated in the middle of the conglomerate series, Colonel Gutbier has collected and described about sixty species of *Calamariæ*, *Filices*, *Selagines*, and *Coniferæ*; of these forty are considered by the author to be peculiar to the Permian, three of them being also found in the Permian group of Russia (*Calamites gigas*, *Sphenopteris erosa*, and *S. lobata*). On the other hand, seven of the sixty species described are considered to be forms known in the Coal-measures*.

In relation to the adjacent region of Saxony, we think it right here to allude to various outbursts of porphyry, and to wide extensions of the Rothe-todte-liegende and its subjacent coal strata, as existing near Zwickau, Chemnitz, and other parts of Saxony, where the coal, on the authority of Prof. Geinitz, lies invariably beneath every stratum to which the term "Rothe-todte-liegende" can be applied. In these tracts, as well as in the environs of Dresden, the lower division of the red rocks is composed of sandstones and shale, and the upper portion alone near Dresden (according to Geinitz) is a coarse conglomerate. In traversing the country from Freiberg to

* Versteinerungen des Permischen Systemes in Sachsen, von A. v. Gutbier. Dresden and Leipsig, 1849.

Dresden, we were much struck with a natural section which exhibits the intimate dependence of this coarse conglomerate upon contiguous eruptions of porphyry. On quitting the plateau of the so-called "gneiss" of Freiberg (a crystalline stratified rock, which we have elsewhere speculated upon as being probably nothing more than metamorphic Silurian*, and which is penetrated here and there by granite), we passed over a great breadth of red porphyry, on the western boundary of which, and in the deep gorge of Tharandt, the igneous rock is exposed in towering pinnacles, and is clearly seen to have penetrated the gneiss, which extends eastwards to near the village of Hainsberg. On approaching the latter place, powerful conglomerates of the Rothe-todte-liegende are seen resting in inclined positions on the eastern flank of the gneiss and crystalline rocks. These conglomerates, which are considered by Geinitz to lie in the upper part of the formation, are made up essentially of the gneiss and granite of the adjacent hills through which the porphyry has risen up, and have therefore directly resulted from that intrusive igneous agency. The blocks are often of several feet diameter, and on the whole the mass reminded us much of the coarse conglomerate of the Old red sandstone on the north flank of the Ord of Caithness.

In the deep ravines E. of Dresden, leading into the Plauensche-grund, into which, in company with Prof. Geinitz, we descended from plateaus of overlying horizontal sandstones of the Cretaceous group, we examined other rocks of the Rothe-todte-liegende which there overlie the coal, and saw the following descending order:—1. Conglomerate. 2. Variegated deep red shale with green spots. 3. Pink-coloured porphyry, which, though a true igneous rock, is as regularly stratified and jointed as the red strata with which it alternates. It is the "Schlam-lava" of Geinitz, and offers in truth the most perfect evidence of having been a *coulée* formed during the agglomeration of the Rothe-todte. Thus far the section is open to view on the side of the hills; the remainder is known through the sinkings for the underlying coal. According to the working plan of a very intelligent manager of the works at Häinichen, the shafts passed down through about 500 feet of other massive alternations of the Rothe-todte, alternating with porphyries, before the first traces of coal were reached. The best bed of coal has a thickness of about 3 feet, and was first worked at a depth of 158 lachter or about 1100 English feet. It was soon lost in this its first and horizontal position, and was subsequently regained in *a highly inclined position* on the slope of the hill, 48 lachter beneath the upper level. When we visited the spot another sinking was being made somewhat lower on the hill side, through 800 feet of the Rothe-todte, to win the coal in a deeper part of the valley. The works in the Plauensche-grund leave therefore no room to doubt, that whilst the coal strata were here originally quietly deposited on gneiss and other ancient rocks, they were subsequently penetrated by eruptions of porphyry accompanied by great dislocations, which broke up the carboniferous rocks and left them at the very different levels and at

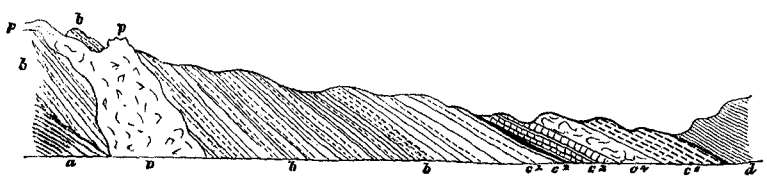
* 'Siluria,' p. 361.

the various angles of inclination which they present to the miner who explores them. This tract offers clear evidence, that the porphyritic eruptions were not only violent, but successive and numerous during the period of the Rothe-todte-liegende, and that they overflowed strata of that formation in the form of submarine *coulées*. Here also, as indeed in many other parts of Central Germany, we learn how these dejections of contemporaneous porphyry and amygdaloid have been occasionally so mixed up with pebbles and sand of the then existing sea, as to render it difficult in such cases to decide whether the stratum should be considered as one of igneous or of aqueous origin. In all such extreme examples, however, the geologist who is seeking after a truthful explanation of the works of nature will admit that such strata are not to be dogmatically defined by one mineral term only, but that, like the volcanic grit or ash of earlier periods, they are to be viewed as true indications of the internal heat of the crust, which, in bursting forth repeatedly, gave rise to those peculiar deposits which resulted from a combination of subaqueous and volcanic causes.

Weiss- or Grau-liegende—Kupfer-schiefer—Zechstein, &c.

Weiss-liegende.—The sandstones, breccias, and conglomerates of which we have just spoken are succeeded in this region, as in many other parts of Germany, by a band differing from all beneath it in its light grey or whitish colour, as derived from a quantity of pebbles of white quartz in a grey paste. This is truly a conglomerate made up of rounded small stones, which present all the appearance of having been formed by waves upon a shore. Since it forms the natural base of the Copper-slate, the miners necessarily applied to it the name of "liegende," as underlying the productive mineral stratum. This bed or band (for it varies in thickness from 3 or 4 feet to 30 or 40) may be properly considered the base of the Zechstein or Magnesian limestone division of the Permian rocks, since in it, after ascending through the siliceous strata of the Rothe-todte-liegende, we first find calcareous matter beginning to show itself, and with it a few rare fossils.

Fig. 4.—*Diagram showing the Succession of the Permian Rocks on the Flanks of the Thüringerwald.* Horizontal distance about 4 miles.



d. Lower Bunter.
*c*5. Sandschiefer.
*c*4. Upper Zechstein (Dolomite).
*c*3. Lower Zechstein.
*c*2. Kupfer-schiefer.
*c*1. Weiss-liegende.
b. Rothe-todte-liegende.
Permian Rocks.
a. Coal-strata (Upper Coal).
p. Porphyry.

The accompanying diagram (fig. 4) shows the position of this Weiss-liegende, c^1; and the open section in which we best saw it, as

there represented, is to the S.W. of the village of Schmerbach, not far distant from Waltershausen near Gotha, where it rests on unequivocal Rothe-todte-liegende, in the form of red and green spotted sandstones, flagstones, &c.

Kupfer-schiefer.—At the same place, we also examined the exposure of the justly celebrated bituminous black schist called Kupfer-schiefer (fig. 4, c^2), which having been followed from its outcrop, like that which is represented in the diagram, has been worked from beneath overlying deposits throughout such extensive districts of Central Germany. Though here only exhibiting a thickness of about 5 feet, this black schist is most neatly defined in its position between the grey pebbly rock beneath and the overlying bands of limestone. The schist is little cupriferous at this spot, but we found in it many fragments of the characteristic fossil fishes.

Zechstein and Sandschiefer.—Above the Kupfer-schiefer follow thin stratified layers of marly limestone (fig. 4, c^3), on which the thick masses of Zechstein repose, that contain the *Productus horridus* and many other fossils. With its lateral extension this formation assumes varied mineral characters, some of which are more decisively impressed upon it in certain localities than in others. Thus, extending from Eisenach by Heiligenstein and Seebach to Schmerbach, Fischbach, Ilmenau, Konigsee, and Saalfeld, on the north-eastern flank of the chain,—or by Altenstein, Liebenstein, Herges, Eisfeld, and Haich near Kronach, on the south-western flank, the ordinary limestone passes up into, and is often entirely represented by, thick masses of true dolomite. This dolomite, in which organic remains are found, as well as in the adjacent marly limestone, forms highly picturesque cliffs, particularly around Liebenstein, the vertical faces of which are frequently marked by natural openings leading into extensive caverns, occasionally containing in the detritus of their floors the remains of extinct fossil mammalia.

It is also in this zone, and chiefly where the rock is a dolomite, that the great gypseous masses which so characterize the German Zechstein occur; and of these we shall have occasion to speak more at length in treating of the region of the Harz. In the region now under review, the largest natural exhibitions of these gypseous rocks which came under our notice lie immediately to the east of Saalfeld, or near the foot of the lofty escarpments of the overlying Bunter-Sandstein.

At Rheinhards-brunnen, east of Gotha, a large mass of gypsum, which has been opened out by a gallery, is here so highly crystalline and transparent, that it forms (under the name of the Glas-hohle) an object of great attraction and wonder to numerous tourists *.

It is also to be remarked, that iron ores, both the "braun-eisen" and spathose varieties, are extracted from the dolomitic or Upper

* Her Majesty the Queen visited this splendid cavern in 1845, and H.R.H. Prince Albert transmitted some magnificent specimens of the crystallized gypsum to England, one of which is to be seen in the mineralogical gallery of the British Museum.

Zechstein at Kamsdorf near Saalfeld, where they occupy two beds, described by Richter *.

The natural capping of the great masses of the Zechstein and Dolomite with its gypsum consists of the regularly bedded brown-coloured impure fetid limestone, called Rauch-kalk, in which the characteristic fossils of the formation cease.

According to the classification proposed by one of us, there are, however, yet some other overlying beds (fig. 4, c^5) which form the natural summit of the Permian rocks, but which have hitherto been classed by German geologists with the Bunter-Sandstein or base of the Trias. In numerous sections they are indeed seen to lie in the same ridge with the Zechstein and to constitute its cap. They are the lowest part only of the Bunter-Mergel of Credner (also Sand-schiefer or Sandige Mergel-Schiefer of that author), and are finely laminated and sandy marlstone, occasionally exhibiting a mineral transition through their calcareous contents into the underlying Zechstein on which they repose.

We have for some years thought that the Bunter-Sandstein of Central Germany ought fairly to be deprived of this inferior member, because it has never offered any Triassic fossil, whilst it has been found to contain a Calamite more allied to the palæozoic than to the mesozoic deposits, and also because it is physically and mineralogically connected with the Zechstein. But these reasons could not alone have led to our including this band (fig. 4, c^5) as the upper limit of the Permian, *had not our survey of Russia taught us, that over very extensive regions, the fauna and flora*—i. e. *reptiles and land plants of true Permian characters, and which are characteristic of the Zechstein zone of Germany—ascend in Perm, Orenburg, Kazan, &c., far above that zone into red sandstones, marls, and conglomerates.* In that vast country, where there are no inversions of the strata, and where the beds are nearly horizontal, there can be no mistake. Hence, until some fossil evidence shall invalidate our inference founded on such good proofs, physical and zoological, we shall continue to class the unfossiliferous bottom rocks of the hitherto so-called Bunter-Sandstein of Germany with the Permian group. In fact, our English sections of the true Permian series where it is best developed, as in Nottinghamshire and Yorkshire, sanction this classification. In his excellent memoir on the Magnesian Limestone, Prof. Sedgwick has shown, not only how the Lower Red Sandstone is surmounted by the equivalents of the Kupfer-schiefer and Zechstein, but also how the last-mentioned is capped by red and green marls, which he associated with the subjacent calcareous masses †.

The fossils of the Zechstein have been so long studied by German naturalists, that if such were our object, we should have to refer to a variety of works for a complete acquaintance with them. Recently Professor Geinitz described many new species, and subsequently M. v. Schauroth ‡ has added other forms new to science, and has concluded his memoir with a valuable table, in which all the species of plants from Algæ to Coniferæ, and of animals from Zoophytes through Molluscs and Crustaceans to Fishes and Reptiles, which are common to Germany, Great Britain, and Russia, are specially marked. By this comparison we learn, that out of one hundred and thirty-eight species known in Germany, sixty-nine or one half are British forms; twenty of these German species being found in those vast eastern provinces of Russia, whence the name of Permian was derived. In short, we see in the Permian that which is common in our own Isles throughout the palæozoic rocks, and on which we have previously dwelt, viz. that each natural group is characterized by a central mass of limestone, in which the fossils prevail, and from which they diminish upwards and downwards as the rocks pass into sands, shale, or other strata void of or slightly charged only with calcareous matter.

* Einladungs-Programm der Realschule, &c. (p. 21), 1853, Saalfeld.
† Trans. Geol. Soc. Lond. 2nd ser. vol. iii. p. 37.
‡ Zeitschrift, Deutsch. Geolog. Gesell., Band vi. p. 539.

In the Permian rocks, then, of the Thüringerwald and other parts of Germany, we consider the Zechstein to be their calcareous centre; for the æra of the Rothe-todte-liegende was, on the whole, too turbulent and its sediments too much charged with iron oxides to lead us to look in them for any good examples of organic remains. In fact, a very few fragments of plants, including the well-known stems of Ferns called *Psaronites*, are all that we usually detect in the deposit, though in certain localities where the physical conditions have been favourable, as in the claystone between the conglomerates in the environs of Zwickau and in two or three spots in Saxony, an abundant flora has rewarded the researches of Colonel Gutbier *.

Now, in Russia, the physical conditions do not exist which in Germany satisfactorily account for the restriction of the fossils to one calcareous zone. In the first place, there is no great coarse conglomerate or trappoid breccia beneath the limestones, but simply some grits and sandstones with plants, &c. Again, the calcareous matter, instead of being confined to one zone, reoccurs even in the form of limestone at several levels (bands of red and variegated sandstone being interlaminated), whilst the whole of the limestone is crowned by coarse conglomerates and sandstones infinitely more resembling the Rothe-todte-liegende than any of the subjacent strata. It is in this upper band that the remains of reptiles belonging to the group of *Protorosauri* have been found, which in Germany is found beneath the limestone. It is, indeed, in these overlying sandstones and conglomerates that most of the plants of the Permian or quasi-Carboniferous type occur, the same upper zone being also that which is so extensively charged with copper ore, that mineral being in Germany invariably *beneath the limestones*.

From these evidences, therefore, which are positive, and are not discountenanced by any data in Germany, we adhere to the classification of the Permian group as originally defined by Murchison and his associates De Verneuil and Keyserling.

* Out of sixty species of these Permian plants, forty are peculiarly Permian, and of these several are identical with forms brought from *strata which lie above all the Zechstein bands in Russia.* See Verst. Perm. Systm. in Sachsen, Heft 2.

Base of the Mesozoic or Secondary Rocks, viz. the Trias.—Without having any pretension to describe the older Secondary rocks or Trias which on all sides overlie the palæozoic rocks of the chain of the Thüringerwald, and occupy all the interjacent country extending northwards to the Harz, we can scarcely avoid calling the notice of English geologists to some of their leading features.

We have already said that no animal remains have been detected in the Lower Bunter-Sandstein which forms the base of the Trias of the German geologists. Nor are we aware of any such remains having been discovered, except in the upper division of the formation and not far beneath its junction with the lower strata of the Muschelkalk.

Wherever the sandstone has been found to be fossiliferous, whether at Hilburghausen near Coburg, where the celebrated footprints of the *Cheirotherium* are found, or at any locality which has yielded the remains of large Saurians (*Trematosaurus, Capitosaurus, Metopias, Nothosaurus,* &c.), it is the superior band of sandstone in which they are found,—a rock which is separated by a vast thickness of strata from the Zechstein deposit and its natural capping. All these intermediate strata of the so-called Bunter-Sandstein, in which no remains of fossils have been detected, constitute therefore what must at least be called debateable ground by all geologists who classify formations according to their imbedded remains. Nor can the field observer who may work out his inductions by the collocation and mineral character of the rocks offer any good reason for attaching these intermediate red sandstones to the Trias above, rather than to the Permian below them. For, as has been already shown, certain Permian animals and plants rise high into those red sandstones and conglomerates which in Russia lie above the Zechstein.

As far, therefore, as evidences go, they are, I repeat, entirely in favour of our placing the upper limit of the Permian higher than it has been provisionally drawn; since if the Russian analogy is found to hold good in Germany, our associates in that country must necessarily separate all the Lower Bunter from the Trias and class it with the Permian. Even when we refer to mineral characters and the nature of the physical sequence, we can find in Germany no reason whatever for placing the lower limit of the Trias where it now stands according to native authors. If lithological distinctions be appealed to, we see good spotted sandstones, red, white, and green (particularly in Saxony), both below and above the Zechstein, thus exhibiting the Permian as a Lower or *Palæozoic Trias.*

Now, the Permian, which is thus a Lower Trias, is everywhere throughout Germany completely conformable to the original and superjacent Trias, which, having the great and widely extended Muschelkalk as a central limestone between two formations of sand and red marl, was justly so named.

Without a break, and without the trace of eruptions, which, perforating the lower strata, have spread out their *coulées*, cinders, and ashes in those contemporaneous sheets which abound in the subjacent palæozoic rocks, the highest Permian strata, *i. e.* from the

Zechstein upwards, graduate insensibly by mineral characters into the Lower or unfossiliferous Bunter, or the Uppermost Permian of our sections. The next overlying mass, which we consider to be the real Bunter, with its upper courses containing fossils, gypsum, and some calcareous matter, forms the true natural-history base of the original Trias. Then comes the Muschelkalk with its lower band of thin wavy or undulating flaggy limestone, known as "Wellenkalk," its central mass with gypsum, and its superior division a limestone;—each locally characterized by certain species of fossils. Lastly, we have the Keuper marls and sandstones, with a base called Letten-Kohle (from certain thin layers of carbonaceous matter contained in it), a middle band with gypsum, and a third or Upper Sandstone on which the Lias rests.

Whilst all this Triassic group has, through its imbedded fossils, whether animal or vegetable, a community of character, the dominant types being found in its great calcareous centre (including many Saurians and Fishes and a rich invertebrate fauna), there are not in the whole group any forms identical with what existed at the close of the Palæozoic æra. An entirely new creation succeeded in this first stage of Mesozoic succession; and yet this wonderful change in life was unaccompanied by any visible interference with the regular increment of submarine and estuary matter, and without any dislocations or disturbances of the successive sea-bottoms in which the fossil animals are imbedded.

We have dwelt pointedly on this great feature of geology in other works*, but we revert to it specially on this occasion, since, as far as we know, there are no tracts in Europe in which the conformable succession of the uppermost palæozoic and the lowest mesozoic, as characterized by distinct relics, is so well exhibited as on the flanks of the Thüringerwald, and in the region lying between that chain and the Harz,—a vast trough, in which the grand undulations of the Trias are so clearly exposed.

PART II.

THE HARZ.—Long as the Harz Mountains have been explored by naturalists, and well as their mineral composition and fractures are known, through the labours of Von Buch, Hausmann, and others, their true geological history is yet far from complete. Referring little to the numerous mineralogists who formerly wrote on this small but highly diversified excrescence on the surface of Northern Germany before its palæozoic classification was attempted, we can now do little more than offer some additions to a memoir written in the year 1839, and published in the Geological Transactions by Sedgwick and Murchison. In that Memoir it was shown, for the first time, that a large portion of its so-called "grauwacke and quartz rocks" was of no higher antiquity than our British Lower Carboniferous deposits, and was the true equivalent of the "Culm" series of schists, limestones, and grits of Devonshire;—that a great mass beneath the above,

* See particularly 'Russia in Europe,' vol. i. p. 582; 'Siluria,' p. 464.

consisting of limestone and schists, was of the same age as those strata to which we had then just assigned the name Devonian; and the belief was expressed that, whilst certain shelly sandstones (Rammelsberg near Goslar) probably stood in the place of the uppermost Silurian, the rocks occupying the south-eastern portion of these mountains, and in which at that time a very few imperfect Trilobites only had been found, would prove to be among the oldest in the chain.

Though it formed no part of that earlier sketch to describe the secondary deposits which range along the northern flank of the ridge, still, as on two different occasions the authors had cast a rapid general glance over them, they indicated some of their chief dislocations and remarkable inversions of order. They also treated of the probable periods at which the granite of the Brocken and other igneous rocks around that mountain had been erupted.

At that time, however, the "Zechstein" was classed with the Secondary rocks, and not grouped, as it has since been, with the "Rothe-todte-liegende," so as to constitute that which one of us has since termed "Permian."

A notice like the present, which is brought before the Geological Society after an interval of fifteen years, must necessarily indicate other features and new bases of classification, the result of recent researches and comparisons. At the same time, it is due to Prof. Sedgwick and his coadjutor to state, that their views regarding the "Culm" strata and the underlying Devonian limestones and schists, as well as their opinion that the south-eastern portions of the Harz were older than the western limits, have all proved to be correct. In short, the general order of superposition of the strata, since called "palæozoic," which was then indicated, is accurate. The only changes made are palæontological, not stratigraphical, and consist in the application to the Harz of that portion of the classification by organic remains, established in the Rhenish provinces by Ferdinand Roemer and the brothers Sandberger, whereby the sandstone charged with large "Spirifers" has been abstracted from the Upper Silurian of the original sketch alluded to and classed as "Lower Devonian," a change, which has, indeed, been long ago adopted by ourselves and all geologists.

In the present communication we shall therefore in the first instance simply attempt to give a general sketch and fill up some lacunæ of detail in the distribution of the palæozoic rocks of the Harz; leaving it to native geologists to complete what is still wanting, a full illustration of this convulsed, mineralized and metamorphosed region,—a task which, however difficult of accomplishment, has been commenced by M. Adolf Roemer, by the publication of a geological map.

General view of the order in which the Palæozoic Rocks succeed each other in the Harz.—In a tract so perforated by igneous rocks of various characters, and where, as we approach the chief axis, or that of the Brocken, even the carboniferous or culm rocks are often in a crystalline condition and in inverted positions, it is hopeless to look for clear evidences of the general succession of the strata. Nor can we expect to find satisfactory proofs of order in the highly mineralized masses which range from Clausthal by Andreasberg towards Hasselfeld, where deposits of very different age lie frequently in juxtaposition, and are often highly altered, and enclose veins of argentiferous galena, copper, &c.

At the south-eastern extremity of the region, and where the mountainous outline subsides into featureless low hills and plateaux, the river Wippra, flowing in a deep valley, exposes peculiar crystalline rocks. These consist of masses of glossy, thinly foliated, grey and greenish "shillat" or chlorite slate, with innumerable subordinate laminæ of white quartz. On the north bank of the gorge these strata are well exposed on the sides of the steep precipitous road which descends to the village of Wippra, where they are vertical or very highly inclined, with a strike from N.E. to S.W. Though we followed the Wippra valley, by the picturesque Schloss * of Rammelsberg and its eruptive rocks, amidst a reddish-coloured grauwacke, to Biesengerode, Vaterrode, and Lembach to Mansfeld, we could see no natural sections exhibiting any consecutive order until we met with the conglomerates of the Rothe-todte-liegende, lying unconformably on older strata, "grauwacke," the white quartz bands of which had evidently afforded the pebbles of the red conglomerate.

We incline to the belief, that the glossy chloritic and quartzose slates of the Wippra are probably the oldest in the chain, and for the following reasons:—First, that we are unacquainted with any rocks like them in the general series of deposits of the Harz (which we are about to notice), whilst they bear a strong mineralogical resemblance to the oldest sediments of the Thüringerwald. 2ndly. That the Wippra schists most resemble (if indeed they are not a southerly extension and probably an inferior portion of) those adjacent strata near Harzgerode, which, judging from the fossils, are supposed to be of Upper Silurian age. As, however, no country can well be more featureless and obscure than the tract between the Wippra and Harzgerode, we offer this surmise with caution; the more so, as the only rocks visible in the intervening tract are a few bosses of greenstone or other igneous rocks with contorted flinty slates (Kieselschiefer).

Silurian rocks†.—In the tract extending from the environs of Harzgerode on the east towards Guntersberg, Hasselfeld, and Andreasberg on the west, a series of low undulations expose here and there bosses of limestone, in which fossils have been detected at a few localities only. In one of these masses of limestone, as exposed to the west of Harzgerode, and formerly noticed by Sedgwick and Murchison, and also in another a mile or two further to the west, at

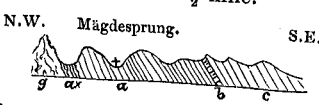
* We are not aware that any other British geologists, except ourselves, have examined the banks of the Wippra.

† Since this memoir was read, I have been informed that M. Ad. Roemer has discovered *Graptolites* in some of the schists of Lauthenthal, and the existence of true Silurian rocks in the western as well as in the eastern Harz is thus indicated.—R. I. Murchison, Sept. 11, 1855.

the lime-works of the Silber-Hütte, a few imperfect fossils were long ago observed. At the latter, a limestone subordinate to greenish and greyish schists is followed upwards by a much coarser grauwacke, which becomes almost a conglomerate. Here the strike is nearly N. and S. and the dip E.; but, as the dips of these schists, grits, and calcareous interpolations frequently change, we now only notice the direction and inclination of the beds at the Silber-Hütte, because the strata there have a strike transverse to the usual direction of the older rocks.

Passing into the Selke-Thal, the continual undulation of the strata is well seen in the gorge between Alexis Baden and Mägdesprung. Unable to decide, in a rapid survey of this confused tract, whether the rocks at Alexis Baden lie over or under those of Mägdesprung, we met at that place with strata well exposed in quarries on the left bank of the Selke, which have been much opened out in the years which have elapsed since they were examined by Sedgwick and his coadjutor. There the succession is decidedly exposed, and thanks to the labours of M. Bischof, Inspector of Mines, a rich collection of fossils has been made, which, as we think, determines one mass of these rocks (*i. e.* the calcareous member of them) to be Silurian. (See fig. 5.)

Fig. 5.—*Section of the Upper Silurian Rocks at Mägdesprung.*
Distance $1\frac{1}{2}$ mile.



c. Schists and sandstone.
b. Limestone with Upper Silurian fossils.
a. Flagstones with Plants.
*a**. Altered schists.
g. Greenstone and other eruptive rocks.

The inferior strata visible, as exposed in the so-called "Treppen Stufen" or great flagstone quarries opposite the hamlet of Mägdesprung, have the normal strike of N.E.–S.W., and dip to the S.E. at 65°. They are very fine-grained, have glossy surfaces, and are of bluish-grey, purple, or greenish tints, so that they are distinguishable in mineral aspect from both the ordinary Devonian and the Culm rocks of the chain. Either they have no cleavage, or the divisional planes are coarse and coincide with the bedding. The flagstones, the varied green and grey tints of which indicate the successive strata, are cut across by devious and irregularly meandering clefts called "Stossen" by the workmen. These are frequently accompanied by quartzose veins, and when they approach to horizontality are made use of by the workmen as stages or tops and bottoms for quarrying out the flagstones. The slabs are often of very large dimensions, whilst their surface, exhibiting undulation and ripple-marks, leave no doubt of the true nature of their bedding. This is, indeed, still more unequivocally proved by their exhibiting (though very rarely) traces of plants and apparently the trails of animals. Some of the plants have the aspect of forked seaweeds; but one large and true land plant has also been found, and has been called by M. Adolf Roemer a *Sigillaria*. On the whole, these flagstones, which when extracted are occasionally 10 feet by 7 feet, reminded us in their aspect of the Scottish Arbroath paving stones, and the so-called Valentia slates of Ireland, both of Devonian age *.

Plunging distinctly at 65° to the S.E., these strata are followed by others slightly differing in mineral characters, but which, being little cut into, are not so well known as those at the works of Mägdesprung; but the apparent ascending order is unambiguous in exposing a seemingly conformable succession upwards, with a dip to the S.E. for about half a mile, until a band of limestone (*b*) is reached, in which the numerous fossils have been found which constitute the Silurian collection of M. Bischof. This limestone, from 30 to 40 feet thick, is hard and crystalline, of dark grey colour with white veins, rough to the touch, and is separated into a lower and upper portion by a thin course of schist. In another layer of schist which immediately overlies the limestone, we detected innumerable small *Tentaculites* †. In the mass of the limestone M. Bischof collected numerous organic remains, of which we will only now allude to those that best prove the rock to be of Upper Silurian age: some of them we now exhibit. Thus, among several genera of *Trilobites* we recognized *Calymene, Acidaspis, Lichas,* and *Cheirurus,* common in Upper Silurian and unknown in Devonian rocks. These, however, are associated with *Phacops* and *Bronteus,* which chiefly prevail in the Devonian. Among the mollusca are *Leptæna transversalis,* and *L. borealis* and *L. robustus* (Barr.), *Nerita haliotis, Orbicula Forbesii, Acroculia depressa* (*haliotis,* Sil. var.), *Orthis alata,* together with the corals *Favosites Gothlandica* and *Cystiphyllum turbinatum.* Again, whilst the above are unquestionably Silurian, *Terebratula princeps,* and some other forms, indicate a close approach to the Devonian.

These fossiliferous flagstones, schists, and limestone are surmounted by a coarser grauwacke approaching to gritty sandstone,

* In a memoir recently published in the 'Palæontographica' of Dunker and Von Meyer (Cassel, 1855), M. Adolf Roemer, in further describing the structure of the Harz, has given a map of the tract around Elbingerode, which represents a considerable band of Silurian grauwacke with an included limestone along the north flank of the chain, S. of Wernigerode, followed by various subdivisions of the Devonian series from the Spirifer-sandstone through the Wissenbach schists, Stringocephalus-limestone, grauwacke, schist, and schaalstein to the Iberger or Upper Devonian limestone.

In the short notices prefixed to the descriptions of the fossils, the author has misunderstood the opinions I formed as to the age of the limestones of the Schneckenberg near Harzgerode, and of the flagstones with plants near Mägdesprung. With regard to the former, I did not see sufficient fossil evidence to enable me to come to a decisive opinion, though it is probable, judging from some of the forms described by Roemer, that the rock may be Upper Silurian.

The age of the flagstones of Mägdesprung with plants has been regarded by me in the text as Devonian,—and not Silurian, as stated by Roemer. The recent discoveries of large land-plants low down in the rocks of Devonian age in Caithness would seem to sustain this suggestion.—R. I. M., Oct. 12, 1855.

† Resembling *T. lævis* of the Devonian rocks, but probably another species.

and that again by finer schists (fig. 5, *c*). As, however, we could hear of no limestone nor fossils in those masses, and had little time at our disposal, we did not explore them to the edge of the chain, where they are overlapped unconformably by some Upper Carboniferous strata, the latter being covered by conglomerates of the Rothe-todte-liegende. (See Trans. Geol. Soc. 2 ser. vol. vi. p. 295.)

But whilst we thus recognized the existence of an Upper Silurian rock in the limestone near Mägdesprung, we were unable to follow it upwards to a junction with strata unequivocally Devonian, or downwards to any other Silurian rocks.

In fact, no sooner do we issue from that portion of the Selke valley, in which for a very short space there is a connected and ascending series, and proceed towards Gernrode and Blankenburg on the north and west, and Alexis Baden on the west, than we meet with much eruptive rock (fig. 5, *g*), principally "gabbro," greenstone, hypersthene, and granite, all of which rising to considerable heights cut off the sequence and exhibit on their flanks many examples of altered strata. (See Section fig. 5, *a**.)

Penetrated as the tract is by such eruptive rocks, and obscured in great parts by wild woodlands, it is manifestly impracticable with our present knowledge to affirm that the strata near Mägdesprung, as exhibited in the Section fig. 5, are not overturned. The large plants found in the flagstones are unlike anything ever detected in Silurian rocks, and resemble Devonian, if not Lower Carboniferous forms. Again, whilst the animal relics of the limestone are said to approach most in character to Barrande's *uppermost* Silurian of Bohemia, they make (according to Mr. Salter, who has examined the specimens we have collected) a very near approach to Devonian, and contain some species which are certainly of that age.

Seeing the amount of protruded igneous rock to the west of these strata of Mägdesprung, we must leave it to be ascertained by future researches in this most dislocated tract, whether the flagstones of Mägdesprung are not of younger age than the limestone, and that the whole series has been inverted. Such inversion would indeed surprise no geologist who knows the Harz; for on the northern flank of the chain the Permian and Secondary rocks are occasionally seen in overturned positions; the younger strata underlying the older.

If M. Adolf Roemer's first map be appealed to, we see in it a confirmation of this idea; for, according to his view, the culm or Carboniferous masses are usually interpolated between the chief eruptive rocks and the Devonian and Silurian groups!

Other rocks containing Upper Silurian fossils have been discovered in a very small patch or two only on the northern flank of the granitic axis of the Ross-Trappe near Ilsenburg, and particularly by M. Jasche of the latter place. We visited one of the localities, called Klosterholz, accompanied by that gentleman, and found there a small portion of dark limestone, which had been formerly quarried for mining purposes, on the side of a rivulet in the woodlands which there slope rapidly from the chain. But no physical features of other rocks are there visible. It is simply a boss of hard lime-

stone on the grassy flank of the Patter Berg, and which, having no visible relation to the altered grauwacke or eruptive rocks of the mountain on the south, is at once succeeded on the north by mural and more or less vertical Zechstein with gypsum, followed by Muschelkalk and other secondary formations up to the Chalk inclusive. Debarred therefore from pronouncing any opinion respecting the relations of the protruding bosses of the older limestone, we have merely to report upon their chief fossils, as extracted by the assiduous labours of M. Jasche, for in our brief inspection we could observe no organic remains in the rocks *in situ*.

Among the fossils collected by M. Jasche*, we saw several which would unquestionably induce us to view them as Silurian; such as a *Pentamerus*, not distant from *P. Knightii*, and very much resembling *P. Vogulicus* of the Ural Mountains; *Orthis antiquata*, and two or three others of that genus, one of which is near to *O. expansa*, another to *O. elegantula*; *Chonetes* (*Leptæna*) *lata* (the small form), *L. depressa*; *Orbicula rugata*, *O. Forbesii*? (Davidson); *Lingula minima*; *Cornulites*, &c. There are also forms of *Terebratula*, such as *T. princeps*, Barr., and *T. melonia*, Barr., which mark the uppermost Silurian of Bohemia, and are also undoubted Devonian types. There are here other forms which unquestionably have more of a Devonian than a Silurian character. Such were the *Phacops* and the *Amplexus*; and to these must be added the *Terebratula princeps*, to which M. de Verneuil (who has seen the collection since we inspected it) attaches great weight as a good Devonian type. Another spot whence M. Jasche has procured many fossils is called Tannenberg, and these have a more Silurian character than those of Klosterholz, including *Cardiola interrupta*, with many Lamellibranchiate shells (*Grammysiæ*, *Cypricardiæ*, &c.), and *Orthoceratites* both large and small.

It is highly probable, therefore, that if all the older palæozoic strata which were originally deposited in this neighbourhood could be detected amidst the dislocated chaotic piles resulting from the eruptions of the granitic and other igneous rocks of the chain, we should meet with links which connect the uppermost Silurian with the true and well-known fossiliferous base of the Devonian, or the "broad-winged Spirifer strata" of the Rhine. Already, indeed, the rock of Klosterholz exhibits an approach to that deposit in the several species of *Spirifer* which occur in it, though none of these are known Devonian forms; still less has the *Pleurodictyum problematicum*, or any of the types common in the lowest Devonian rocks of the adjacent Rammelsberg near Goslar, been found near Ilsenburg. Until better evidences be produced, we would therefore also class these rocks as Upper Silurian, and consider them as a link higher in the series than the limestone of Mägdesprung.

In a memoir recently published†, M. Carl Prediger has, indeed,

* In the 'Palæontographica,' vol. v. part 1, 1855, are detailed descriptions and figures of the fossils from these localities by Adolf Roemer, forming a portion of the 3rd part of his "Geology of the North-western Harz."

† Zeitschrift für die gesammten Naturwissenschaften, Halle, June 1854, p. 34.

thrown some additional light on the western extremity of the region which Roemer has coloured in his map as Silurian; though it must be observed that some of the most unequivocal of our Silurian localities are therein laid down as "Culm." After describing four classes of sedimentary rocks under the terms of Grauwacke, Grauwacke-schiefer, Thon-schiefer, and Quarzfels, besides other rocks of metamorphic or igneous origin, he indicates that which we shall presently speak of as a series of true Carboniferous strata, as originally stated in the 'Transactions of the Geological Society,' 2 ser. vol. vi.

The same author also mentions, towards the close of his paper, a considerable mass of limestone to the north of Wieda which is fossiliferous. Not having seen the organic remains of that rock, we cannot affirm that this limestone is truly Silurian, as believed by M. Adolf Roemer, though, if its organic remains be correctly identified, we have little doubt that M. Barrande would class the rock with the Upper Silurian of the Continent. The fossils are said to be, *Terebratula princeps* (Barr.), *T. bidentata* (His.), *Spirifer cultrijugatus* (Sow.), *Cardium striatum* (Sow.).

Knowing as we now do, that, besides this mass to the north of Wieda, there are numerous other protrusions of limestone which have scarcely been examined, between that place and Harzgerode on the east, and believing that these quasi-Silurian rocks on the south are not separated from the unequivocal Devonian rocks of Elbingerode on the north by any continuous band of eruptive rocks, we trust that, notwithstanding the monotonous and covered outline of the country, closer researches will obtain the requisite proofs of order in an ascending series.

Devonian Rocks.—These rocks occupy altogether a considerable space to the east and south of the northern granitic axis, though seldom in masses of any great, continuous extent. Like all the other sedimentary formations, they occur, for the most part, in disjointed masses, separated either by igneous or highly altered and metamorphosed rocks, so that the true sequence, even from one member of the group to another, is seldom to be detected. The oldest unequivocal Devonian stratum of the Harz, as on the Rhine, is the Spirifer-sandstone with its associated slates and schists. The largest and clearest exhibition of this rock is to be seen in the well-known hill of the Rammelsberg, which overlooks the ancient town of Goslar from the south, and which, owing to the aid of M. Zincken, who furnished us with good fossils, was paralleled by Sedgwick and Murchison with the shelly sandy "grauwacke" of Coblentz. Clearly defined by the presence of characteristic large Spirifers, the *Pleurodictyum problematicum*, a *Homalonotus*, and other fossils, there could be no doubt respecting the age of this subformation, which here, as in the Rhenish provinces, is associated with slaty schists, both underlying and overlying. Thus, near Goslar, the slates of Nordberg, and others to the south of the town, which are truly Devonian, seem, as formerly indicated*, to pass by a great inversion under the Spirifer-sandstone,

* Trans. Geol. Soc. Lond. 2 ser. vol. vi. p. 291.

whilst other schists overlie the latter. To term either of these slaty masses the Wissenbach slates, without the strongest and most copious fossil evidences, would be presumptuous; for even in the Rhenish provinces, the succession on the two banks of the Rhine presents no means of making such close comparisons. In putting forth this caution, and particularly in so convulsed and fragmentary a tract as the Harz, we are bound to state, that M. Adolf Roemer believes, that a course of Lower Devonian or Spirifer-sandstone near Schalefeld and Zellerfeld (which we did not see) is overlaid by Calceola-schiefer, and that the latter, which on the left bank of the Rhine is the well-known base of the Eifel limestone, is surmounted by slates which he considers to be of the same age as those of Wissenbach, because they contain the *Bactrites*, a Cephalopod first supposed to be an Orthoceratite, and peculiar certainly, as far as we know, to the deposit in question. But though peculiar in the Rhine country to the Wissenbach slates, we cannot suppose that this fossil may not be found throughout a considerable thickness of the schistose grauwacke of Lower Devonian age. Not having seen the only locality where this sequence is said by M. Adolf Roemer to be indicated, we must apologize for doubting whether the true order in the Harz differs after all from that established on the banks of the Rhine. Not questioning the sincerity with which M. Roemer has come to his conclusion, we beg to say that in such a complicated and obscure case as that of the Harz, our inference must also mainly depend upon the precision with which the terms "Wissenbach slate" and "Calceola-schiefer" are applied. In speaking of the rocks in the Harz, the geologist who has explored the Rhenish provinces well knows that the Calceola-schiefer of the Eifel or left bank of the Rhine has no exact representative on the right bank, and that the Wissenbach slate of the latter is not recognizable in the former.

Again, supposing that in the localities above mentioned, the strata are truly so named, not merely from the actual presence of one fossil or from lithological resemblance, it must also be shown clearly, in a country where inversions of strata are so very frequent, that the beds are in their normal position.

Passing, however, from this subject of detail, on which we hope to satisfy ourselves on a future occasion, we would next remark, that even the lithological distinctions of the subformations of the Devonian rocks of the Harz are so irregular and fugitive, that the features which are dominant in one part of the tract disappear altogether at the distance of a few miles.

Thus, putting aside what may be considered the equivalent of the Wissenbach slates and Calceola-schiefer of the Rhenish provinces, we see towards the east and in the environs of Elbingerode, and between that place and Hüttenrode, enormous masses of limestone, the lowest of which is unquestionably of the same age as the great Devonian or Eifel limestone of the Rhine; since it contains *Stringocephalus Burtini*, *Bronteus*, and other characteristic fossils.

It is specially this limestone which has afforded such large quan-

tities of iron ore in the Harz. It is often so saturated with iron, that the calcareous portions are just sufficient to serve as a flux for the smelting of the ore. This is well seen at the Blaue Binge Mines in the Bücherberg, north of Elbingerode, of which we annex a diagram to exhibit the contortions of the strata (fig. 6).

There the iron rock, plunging under much schist and interlaminated volcanic ash or "schaalstein," is distinctly overlaid towards Elbingerode by coarse gritty greywacke, and the latter by dark schists; the whole of which are seen to be surmounted by a dark limestone of totally different characters from that beneath. Though much contorted, fractured, and perforated by dykes of black porphyry and bosses of a light porphyry with pinite, this upper limestone, which is highly crystalline, passes at one place into black and in another into variegated coralline marble, and occupies the cliffs of the gorge of the river Bode near Rubiland, and its well-known caverns.

Though fossils are rare in it, *Terebratula cuboides* and other forms elsewhere characteristic of the Upper Devonian have been detected by M. Adolf Roemer;—fossils quite distinct from those of the inferior or Stringocephalus limestone. In passing from the valley of the Bode over the plateau by Hüttenrode towards Blankenburg, the upper limestone is seen to be separated from the ironstone by bands of schists, grauwacke, and schaalstein.

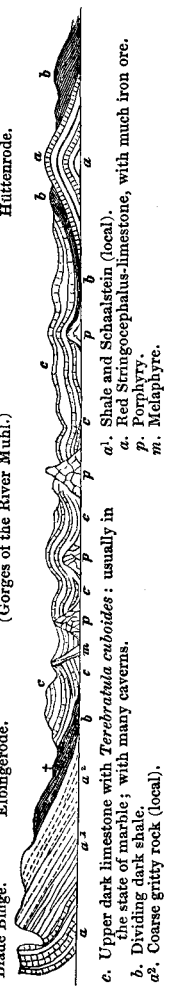
The section (fig. 6) explanatory of this succession is merely offered as a very rude approximation; for whilst we believe that it is correct in presenting a general view of the relation of the two limestones and their separation, we are aware that numberless features of the strata which are not visible at the surface and many points of eruptive rock have been omitted.

Our chief objects, however, in calling attention to these two limestones of Elbingerode and the Bode-Thal are to show—

1st. That even the lowest of them is entirely distinct from the limestones of the adjacent tract on the east, watered by the Selke, and which we have shown to be Upper Silurian.

2ndly. That in following these calcareous rocks westward along the southern slopes of the Brocken to the tracts between Goslar and

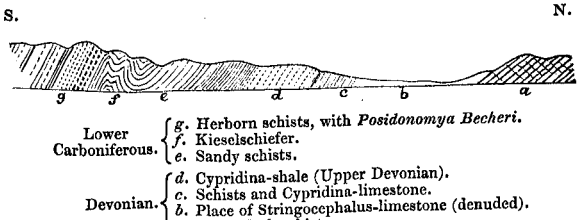
Fig. 6.—*Section showing the general relations of the Lower and Upper Devonian Limestones near Elbingerode.* Distance about 9 miles.



Clausthal, and still more when we pursue them into the Lauthenthal, the lower limestone thins out, and the only calcareous rocks visible between enormous masses of inferior slaty grauwacke with *Bactrites*, called "Wissenbach slate" by Roemer, and the overlying Carboniferous rocks, is that which is clearly the upper limestone, as distinguished by the *Terebratula cuboides* and other fossils.

This is seen at and to the north of the bridge near the mining works of Lauthenthal, in a natural section pointed out to us by M. Ad. Roemer himself (see fig. 7).

Fig. 7.—*Section of the Lower Carboniferous and the Devonian Rocks in the Lauthenthal.* Distance about 2 miles.



Now whether M. Roemer be correct or not, in assigning to the inferior slates of this section the place of the Wissenbach slates, because he has found the *Bactrites* in them, it is manifest that there is here no representative of the Stringocephalus-limestone, for hundreds, nay, thousands of feet of slaty rocks are well exposed between Lauthenthal and Goslar without a course of subordinate or underlying limestone to represent the rocks of the Eifel, which are so clearly exhibited in other parts of the Harz. At Goslar, on the contrary, the only inferior rock met with is, as before said, the Spirifer-sandstone. On the other hand, the ascending section at Lauthenthal is clear. The overlying calcareous strata contain schists charged with *Cypridinæ*, which pass into calcareo-concretionary beds with *Terebratula pugnus*; the whole representing the Uppermost Devonian.

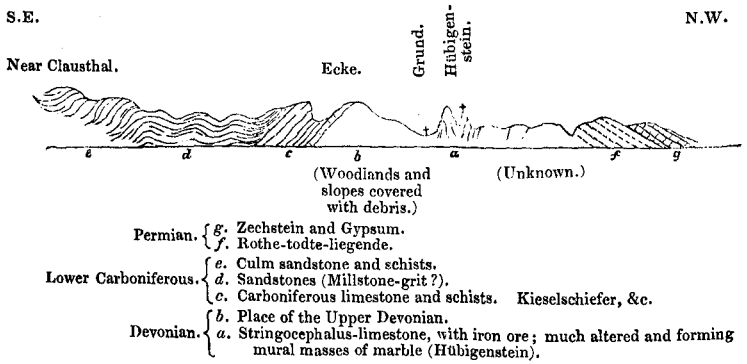
In fact, these masses not only resemble the Kramenzel or "antstone" of the Rhine, which is of that age, but are overlaid by schistose grauwacke, which is immediately covered by the Lowest Carboniferous beds (here in the state of Kiesel-schiefer), and these by other schists which are identically the same schistose representative of the Carboniferous Limestone which at Herborn and so many places in the Rhenish provinces and elsewhere, as well as in the British Isles, is charged with the *Posidonomya Becheri*, as well as with *Goniatites*, Crinoids, and many land plants.

As, therefore, there is no true representative of the Eifel limestone in the Lauthenthal, where the consecutive series is so well exhibited and where so little eruptive rock appears, the reader may judge of the impossibility of reasoning on the general succession from the lithological evidence of any one local section.

This rapid change in mineral conditions is again seen in the west-

ern end of the old rocks of the Harz. We have merely to pass from the Lauthenthal a few miles to the N.N.W., when, instead of the nodular calcareo-schists we have just spoken of as Upper Devonian, we find ourselves at the feet of enormous masses of amorphous crystalline limestone, void of all alternating schists, which stand out from the dense woodlands to the north of the village of Grund. The chief of these is the pyramidal boss called the Hübigenstein. In these altered amorphous masses it is almost impossible to trace stratigraphical relations among the fragments. (See fig. 8.)

Fig. 8.—*Section from near Clausthal to beyond Hübigenstein.* Distance about 7 miles.



Analogically, however, and by comparing them with the rocks of Elbingerode, something may be inferred. In the first place, we see that on its western side, the chief boss of limestone is flanked by highly ferruginous red schists, succeeded by vertical bands of iron-stone, which, if not absolutely in, are clearly associated with Devonian limestone containing corals and exposing traces of beds plunging rapidly at 45° to the S.E. Passing over these you come to the great fissured abnormal masses of limestone (Hübigenstein), on one of which a cross is placed, and in which all traces of stratification disappear. When, however, we know that the *Stringocephalus Burtini*, *Spirifer multirugata*, *Terebratula reticularis*, *Pentamerus galeatus*?, with Trilobites of the genera *Bronteus* and *Cheirurus*, have been found in or near these rocks, there can be little hesitation in saying that we have in them representatives of the Eifel limestone.

Whether the eastern peak of the Hübigenstein belongs to the lower or upper Devonian limestone, it would be difficult to determine from its altered and crystalline aspect; but numerous fossils characteristic of the latter are found in the debris of the adjacent woodlands on the east, which belong unequivocally to the higher rock, such as *Terebratula cuboides* and its associates.

Transition from Devonian to Carboniferous.—We have a still better palæontological proof of an ascending succession in the same

locality from west to east in the fact, that a limestone of another mineral character, which succeeds to the last, contains many highly characteristic fossils of the Carboniferous Limestone. These occur chiefly in detached fragmentary portions of the rock, resulting from partial excavations made by miners in search of ore in the highly mineralized tract north of Grund, where, besides lead, stray veins of barytes are apparent even at the surface.

In the spots to which we were conducted by M. Adolf Roemer, we could indeed detect no physical signs of any order of succession, except the very obscure evidence above noticed in proceeding from those strata on the west, which our contemporary considers to be "Culm," whilst we view them as unequivocal Devonian iron schists, probably lower. We were, however, informed by a miner named Diedrich, who has been the collector of fossils around Grund, that at a spot called the "Ecke," a high point in the wood, which M. Ad. Roemer had not then examined, and about two miles east of Grund, a *dark grey* limestone, as distinguished from the white-veined Devonian rock, occurs in regular beds, exposed in a thickness of about 10 feet (Section fig. 8, *c*).

Whether this collector obtained any of his dark-coloured fossils from this solid rock, or from fragments at other spots, it is manifest that such fossils are nearly all well-known Carboniferous types; amounting, according to Ad. Roemer, to about forty species, whilst the same authority enumerates upwards of two hundred from the adjacent Devonian limestone.

In saying thus much as derived from fossil evidence only, we have introduced a general section across the Hübigenstein (see fig. 8), to show how difficult it is in a hasty visit to assign the true physical order to this distorted, mineralized, and amorphous mass. Obscure as this hilly tract is from its dense woodlands, still a close comparison of the works of the miners—particularly a register of all the strata passed through in a great adjacent adit, which is about a mile in length; to say nothing of the natural features which may be detected in the gorges and the summits,—would no doubt yield up to close researches like those of our Government Survey, much more accurate results than any which have been yet obtained.

In the mean time, the fossils which are found in and about Grund entitle us to say, that they exhibit a transition from true Devonian into the Carboniferous group. They, in fact, quite confirm the description of this tract given in the year 1839, which states, "We have no doubt that the calcareous mass of Grund is a true Devonian limestone, and that the overlying beds are the equivalents of those parts of the Westphalian sections which extend from the great [Carboniferous] limestone to the base of the Coal-measures*."

Carboniferous Rocks.—From what has already been said, it will have been observed, that the lowest members of the Carboniferous rocks, where they are in contact with or pass into the Upper De-

* Trans. Geol. Soc. Lond. 2 ser. vol. vi. p. 289.

vonian, are in one spot (as at Lauthenthal) in the form of flinty slates (Kiesel-schiefer) and Posidonomya schists (fig. 7, *e*, *f*, *g*), while in another locality distant only four or five English miles, they are limestones charged with numerous *Producti* and fossils of the Mountain Limestone (fig. 8, *c*, *d*, *e*).

In its partial appearance and disappearance within very short distances, and in its passage into flinty schist and Posidonomya shale, the Carboniferous Limestone of the Western Harz entirely resembles the rock of the same age in Westphalia, as described by one of us and his companion, and those of the Thüringerwald and Saxony. In no other part of this region, except near Grund, is there any band of Carboniferous limestone like that in question. But its associates and equivalents occur in very many spots, and specially near Clausthal, where some of the richest veins of true argentiferous galena traverse the strata containing the *Posidonomya Becheri*, with occasional hard flinty slate.

These Posidonomya strata, often of very considerable dimensions, and inclined in every direction from verticality to a slight deviation from horizontality, are succeeded upwards by other sandstones and schists, which we considered to be of the same age as the Millstone-grit and Culm deposits of England. Occasionally there are to be seen great masses of thick-bedded sandstone of lightish colours, which were described as having subordinate layers of micaceous flag-stone and dark carbonaceous shale, as well as beds of a very coarse grit, with granules of greasy quartz as large as peas, like some varieties of the millstone grit of Britain.

The greater and uppermost mass of all this series was said to consist of dark shale and schist, with very thin-bedded hard sandstone, containing reed-like and grassy small plants; and this was first compared by Sedgwick and Murchison with the Culm fields of Devonshire.

It would appear that subsequent researches (even to the year 1854 inclusive) have confirmed these early comparisons. Besides the labours of M. Adolf Roemer near Clausthal, where the dislocations are so great as to render it almost hopeless to trace any order, except through the discovery of fossils, we again call attention to the memoir of M. Carl Prediger, who seems to have met with some physical proofs of succession to the south of Andreasberg. The "ältere *Kulm*-grauwacke" of this author is the band which was formerly shown by English geologists to be the equivalent of the Carboniferous Limestone and Posidonomya shale; this "*Kulm*-sandstein" (which in the long ridge of the Bruch Berg becomes, as in the Taunus, a sort of quartz rock) is that which they paralleled with the Millstone-grit; and his "obere *Kulm*-grauwacke" is the Culm-field proper of North Devon, as long ago indicated *.

* We are the more particular in referring the reader to the original comparison by Sedgwick and Murchison whereby these rocks were first paralleled with the *Culm* series of the S.W. of England, because modern German writers, like M. Prediger, seem to ignore the fact. M. Prediger refers to M. Adolf Roemer as the author of a comparison which is, we believe, exclusively that of the English explorers of 1839. See Trans. Geol. Soc. Lond. 2 ser. vol. vi. (Section from Osterode to Clausthal) p. 288.

Upper Palæozoic Rocks surrounding the Chain of the Harz.—The physical feature of the geographical outline of the Harz being at right angles to the ancient strike of the older rocks of the chain, which was formerly noticed by Humboldt, and dwelt upon by Sedgwick and Murchison, is analogous to the phænomenon already pointed out in the Thüringerwald. In the Harz, as in Thuringia, the Permian deposits (with some slight underlying courses of coal, see fig. 10, p. 445) are abruptly and entirely separated from all the more ancient rocks, including the Lower Carboniferous, and form a girdle around an elongated ellipsoid, the major axis of which trends from W.N.W. to E.S.E., or nearly at right angles to the original direction of the older and elevated deposits.

When the original communication above cited was offered to the Geological Society, the formations known as the Rothe-todte-liegende were classed with the Secondary rocks; but since then they have been grouped as Upper Palæozoic, under the name of Permian. In respect to the few shreds of coal which have been detected around the Harz, they all lie, we believe, beneath the red rocks as in Thuringia; and we are now of opinion that in the example of Meisdorf, near Ballenstedt, the coal is not subordinate to the red conglomerate, as was once supposed, but crops out from below it *.

That great red conglomerate and sandstone (the Rothe-todte-liegende), which is the equivalent of the Lower Red Sandstone of Britain, appears as a wrapper of very unequal dimensions around the western, southern, and eastern parts of the chain. Thinly developed to the south of Lauthenthal, between the older slaty rocks and the Zechstein, it is not again visible in proceeding eastwards until we reach the environs of Sachsa and Ilfeld, where it was formerly shown † to be associated in its lower parts with a vast accumulation of newer and quasi-stratified red porphyry,—the "quarz-freier porphyr" of the Germans. In the hill of Kyffhausen, to the south of that tract, many silicified stems of ferns (*Psaronites*) are found, similar to those which occur in rocks of the same age in Saxony and Thuringia.

The clearest and most instructive natural section of this deposit, in a small space, with which we are acquainted, where it flanks the Harz, is at Leimbach, near Mansfeld.

Accompanied by M. Hoffman, attached to the mines of that place, we examined in some detail the hill to the north of it (see fig. 9).

Fig. 9.—*Section of the Permian Rocks at Leimbach.*

Distance about 1 mile.

e. Zechstein. (Bottom beds concretionary.)
d. Red earthy sandstone.
c. Conglomerate with white quartz-pebbles.
b. Deep-red shaly sandstone.
a. Porphyritic and amygdaloidal conglomerate.

* Trans. Geol. Soc. Lond. 2 ser. vol. vi. p. 295. This coal is not now worked.

† See Trans. Geol. Soc. Lond. 2 ser. vol. vi. p. 286, and section fig. 15.

1. Among the lower beds visible towards the west is an amygdaloid (fig. 9, *a*) composed of two varieties of quartzless porphyry, one of which contains small nests of zeolite in a base of felspar-wacke. The other is a sort of "bladder-stein" with green earth, and both are interlaminated with the red sandstone, and are manifestly contemporaneous with the other strata.

2. A thick mass of deep red, earthy, thin-layered sandstone (*b*), containing many grains of whitish felspar. Though not exhibited in the hill of Leimbach, this part of the formation (south of Mansfeld) affords extensive quarries of finely laminated, but thick-bedded building-stone; the beds being separated at intervals by earthy greenish layers.

3. A whitish-coloured conglomerate (*c*), studded with many pebbles of white quartz, doubtless derived, as before stated, from the old quartz rocks of the Wippra Thal (see p. 431). This band forms a striking feature on the hill side.

4. Dark red argillaceous sandstone (*d*), with thin concretionary courses of brown and grey calcareous grit.

5. The underlying strata just described are at once conformably overlaid by about 30 feet of Zechstein (*e*), the base of which, however, is ill-exhibited. It appears that the German miners, who have so accurate an acquaintance with their Kupfer-schiefer, have not been able to detect it here, in its usual place between the lower rock and the Zechstein. The course sets in, however, in that position a little to the east of Mansfeld. This layer, originally deposited in the state of cupriferous mud, must here have thinned out on an ancient pebbly shore, the bed of which now forms the escarpment described. In other and adjacent tracts of Central Germany, its extraordinary persistence over wide areas has already been explained.

The magnificent ruins of the once powerful castle of Mansfeld stand on the upper and pebbly beds of the Rothe-todte-liegende; but great dislocations have affected the flanks of this mass, and no good section like that of Leimbach is there to be seen.

Before we quit the consideration of the Rothe-todte-liegende of the region around the Harz, we beg to state, that, although, as before said, there are very rare occurrences of poor and thin coal in that rock, all the best local authorities, including M. Plumecke of Eisleben, are agreed, that the old coal* properly so called (the Stein-kohlen-gebirge of the Germans) lies entirely beneath the Red rock. Having also interrogated M. Breslau, a practical "bergmeister" who has observed the progress of a great trial for coal now going on near Rotheburg, we ascertained that slightly inclined red sandstone and conglomerate, in which one thin course of limestone without fossils has been noted, have there been pierced to a depth of 1000 feet without a trace of coal. Though the speculators hope to find it beneath the great Red cover, we have already adverted to much deeper sinkings in the same rock, near Eisenach, which have entirely failed.

Zechstein, with Kupfer-schiefer and other associated strata.—In numerous places around the older rocks of the Harz, the Zechstein

* At Wettin, Ilmenau, &c.

and associated strata are extensive deposits which sometimes rest upon the Rothe-todte-liegende as just mentioned, but are often placed at once on the edges of the older slaty rocks. At Osterode and to the W.S.W., the Zechstein is characterized by vast interlaminated bands of anhydrite, which, on weathering, become gypsum.

The fine laminæ of sulphate of lime are quite apparent, and as the beds both repose upon and are surmounted by limestone, it might be inferred by some geologists, that the intermediate beds of anhydrite were formerly carbonate of lime, which have been altered by the transfusion of sulphuric acid.

To the south of Sachswerfen, where the Zechstein reposes on the Rothe-todte-liegende, it is seen to be conformably surmounted by beds of earthy red sandstone; and, although these have been hitherto classed with the Bunter-Sandstein, or base of the Trias, we have already assigned reasons why this lower portion of that rock should be considered as the natural roof of the Zechstein, and therefore classed with the Permian*. The accompanying section (fig. 10), showing a succession from the younger coal-beds, resting against highly-inclined Lower Carboniferous strata, and followed by Permian rocks to the south of the Harz, is taken from the Geol. Trans. 2 ser. vol. vi. p. 286. See also the Diagram of the Permian succession on the flanks of the Thüringerwald, p. 424.

In extensive portions of their range, the chief limestones are dolomites. Near Mansfeld, where the lower part only is seen, the rock is a subconcretionary, flat-bedded, impure, sandy limestone, of dark brown colour, weathering into insulated turrets, like some of the Sunderland beds.

* We much regret not to have had time to visit the remarkable insulated mass of Permian rocks which lies a few miles to the S.E. of Nordhausen. There the conglomerates of the Rothe-todte-liegende contain *Psaronites* (Kyfhausen near Kelbra). These rocks, associated with melaphyre and surmounted by Zechstein, rise up through the wide extent of Trias that lies between the Thüringerwald and the Harz. We hope to explore hereafter this insular Permian mass.

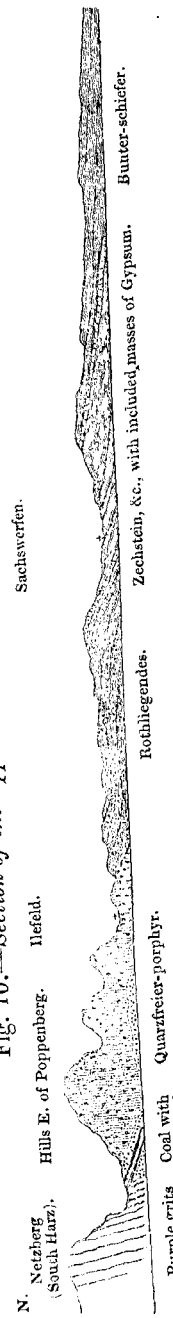


Fig. 10.—*Section of the Upper Coal and Permian Rocks South of the Harz.*

In the environs of Eisleben, however, where numberless sinkings have been made to extract ore from the underlying copper-slate, the miners observe with minute precision the mineral character of every layer of the deposit. The underlying rock is the "Weiss-Liegende," which, as before said, forms the natural base of the Zechstein. This light greyish pebbly bed, of about 3 or 4 feet in thickness, is at once conformably covered, as on the flanks of the Thüringerwald, by the Kupfer-schiefer with its fossil fishes and peculiar flora, all of which are here contained in a thickness of 2 feet. This is surmounted by a little shale and impure limestone, and then by about 28 feet of anhydrite and gypsum, and the overlying succession is made of the alternations of rocks locally called "Asche," "Stinkstein," and "Rauch-kalk."

The lower portion of the Bunter-Sandstein, which immediately rests on the Zechstein, clearly exhibits a passage into it, and forms its natural cover. The lowest of these beds near Eisleben consist of greenish calcareous shale, with concretions of impure limestone, similar to some of the immediately underlying beds of Rauchstein and Stinkstein. Again, in some of the red and green beds, thin courses of coaly matter have been found (Gerdstedt).

Looking, then, at the similarity of these features to those of strata having the same position in the Thüringerwald, we necessarily adhere to the Permian classification already proposed.

Secondary or Mesozoic Rocks.—Though it does not enter into our present plan to describe the succession of secondary rocks, whether triassic, jurassic, and cretaceous, or of the older tertiary rocks, which, flanking the granite of the Brocken and the Rosstrappe, and their associated slaty rocks, constitute the mural, broken, and occasionally inverted bands to which attention was formerly* directed, we think it right, in taking leave of the Harz, to say a few words respecting these younger rocks, if only to show what great movements have affected all the strata from the Bunter-Sandstein to the Upper Chalk inclusive, if not also certain older Tertiary strata.

The Bunter-Sandstein of the Trias, N. of the Harz, contains a very remarkable band of ferruginous pisolite, the "Rogenstein" of the Germans, which to the east of Ilsenburg is exposed in vertical bands †.

Above this rock, and between it and the Muschelkalk, is a lighter-coloured and often yellowish sandstone, in which Saurians occur, including the *Trematosaurus*, the finest specimens of which have been detected at Bernberg, in the north-eastern extension of this formation.

Of the Muschelkalk we will only say that its upturned edges are admirably displayed towards the north-eastern end of the flank of the Harz, between Ballenstadt and Quedlinburg, flanked by the Keuper sandstone.

Above the Trias, the Lias of Quedlinburg is copiously rich in fos-

* Trans. Geol. Soc. 2 ser. vol. vi. p. 291.

† One, if not others, of the magnificent old churches of Brunswick is built of this "Rogenstein."

sils, and is followed by representatives of both the lower and upper Jurassic deposits, often in rapid undulations.

In Hanover and Brunswick the Cretaceous group is singularly well developed: for beneath it there is a genuine representative of the Wealden; whilst the true base of the group is the distinct northern German equivalent of the Neocomian limestone of southern Europe, called here the "Hils-conglomerat." The remainder or really great mass of the Lower Greensand of England has no adequate representative; and the siliceous sandstones, on the north flank of the Harz, which from mineral character were formerly considered as such belong to a much higher member of the Cretaceous series.

The formation, however, which the German geologists term Gault, may be said to represent both the upper portion of our Lower Greensand and the Gault proper. In the interesting collection of M. v. Strombeck, we observed indeed as Gault fossils certain species which are found in our Lower Greensand.

The Lower "Quader Sandstein," in which much iron occurs, and the upper part of which is charged with many green grains, contains the fossils of our Upper Greensand, and is supposed to be of older date than the "Pläner Sandstein" of Saxony.

The Upper "Quader Sandstein," which forms those remarkable walls of rock to the N.E. of Blankenburg, and which were formerly taken for Lower Greensand, is in fact the equivalent of the White Chalk of Western Europe! It contains, in short, many of the most characteristic fossils of that subdivision. The plants collected by the zealous botanist, M. Hempé of Blankenburg, afford an instructive illustration of the fossil flora of these upper cretaceous rocks.

There is still an "Oberste Quader Sandstein," representing the very highest beds of our Chalk.

These siliceous strata, standing in the place of the Upper Chalk, are followed near Goslar by a great mass of whitish chalky-looking rock, which is in truth an old Tertiary rock. This also seems to be thrown abruptly off the chain, in common with the secondary strata.

In thus briefly adverting to the vertical, disrupted, shattered, or convoluted strata of secondary age on the north flank of the Harz, or along its chief granitic frontier, we should do injustice to the subject if we did not call attention to the praiseworthy and precise labours of M. von Strombeck of Brunswick. We visited that city purposely to inspect the collections which that gentleman has made there during a series of years, and were delighted with the clear order in which he had arranged the fossils of his neighbourhood,—from the base of the Trias to the younger Tertiary strata. It is truly a remarkable collection; and, in respect to the magnificent specimens of the *Encrinus liliiformis* of the Muschelkalk, is quite unrivalled. As, however, it would require a separate treatise and a detailed survey of the country to enable us to describe the result of the labours of M. von Strombeck, we confine ourselves to pointing out, in few words, a striking physical phænomenon which he has brought into a clear light, and to illustrate which he has prepared excellent sections, which are not yet published.

The English reader may well be surprised when he learns, that in the comparatively flat region around Brunswick, where the hills are of small elevation only, the secondary strata, though not in such abrupt and broken walls as they occupy alongside of the granite of the Harz, have still partaken of the influence of the same great movements as the formations contiguous to it, though distant about twenty-five miles from that line of eruption, whilst their major axis is precisely parallel to the vertical masses on the north flank of the Harz.

Thus, the strata in question, every member of which has been accurately identified through its fossils, are in some instances seen to have been thrown into sharp and broad undulations, by anticlinal and synclinal flexures, the axes of some of which are actually overturned or inverted, like many well-known examples of the Palæozoic rocks.

In this region such movements have affected all the deposits, from the Palæozoic to the older Tertiary, both inclusive.

Recapitulation.—In the preceding pages we have shown, that of the two chains described, the Thüringerwald only exhibits any of the oldest sedimentary rocks; the strata containing the lowest Silurian fossils being there underlaid, as in Great Britain and Bohemia, by vast masses of slate and sandstone, in which no forms of a more composite structure than Fucoids have yet been detected. These bottom rocks, and the superposed Lower Silurian of that tract, were, it appears, elevated into dry land, and placed during a long period out of the reach of sedimentary influence; since none of those strata of the unequivocal Upper Silurian of Bohemia or the Lower and Middle Devonian, which are so much developed in the Harz, are to be seen in the Thüringerwald.

Towards the close, however, of the Devonian æra, both tracts were again covered by a sea in which animals lived differing from all those which preceded them, whilst the recesses of that ocean, whether in this region or in the Rhenish Provinces, were spread over by volcanic dejections, which were interlaminated with ordinary submarine beds.

These volcanic dejections ceasing, there followed other accumulations of mud and sand, into which stems, branches, and leaves of land-plants were transported, and out of which thin courses of coal were formed.

After these Lower Carboniferous beds had been accumulated, a great upheaval took place over all those parts of Germany and France where such strata occur, and raised up such lower carboniferous beds in conjunction with those which preceded them; the whole constituting the Grauwacke series of the Germans. The next sediments formed on the edges of all that went before them are the feeble equivalents of our Upper coal fields. These again, after partial oscillations, were succeeded by the Rothe-todte-liegende, or Lower red sandstone. Much as each range has been, at various antecedent periods, subjected to eruption of igneous rocks, it was then that one of the most marked of the physical revolutions of this portion of the crust of the earth was accomplished, in the change of the geogra-

[*Quart. Journ. Geol. Soc.* vol. xi. *to face* p. 448.]

THE PALÆOZOIC ROCKS IN GERMANY. (UNDERLYING THE TRIAS.)

Natural Groups.		Divisions.	Subdivisions.	Some Localities.	Characteristic Fossils in Germany.	British Equivalents.
Base of Mesozoic.	Trias.	Keuper.	Upper Keuper and Sandstone, Gypsum, Lettenkohl.	Stuttgart, Coburg, Gotha, Erfurt, Gottingen, Nurnberg, Waltershausen, &c.	Mastodontosaurus, Metopias, &c. (Labyrinthodonts); Nothosaurus, Simosaurus (Enaliosaurians).	"Keuper" Marls and Sands of Worcester, Leicester, Droitwich, Nantwich, &c.
		Muschelkalk.	Upper Muschelkalk.	Weimar, Wurzburg, Jena, S. & N. of Harz, and around the Thüringerwald, Eisenach, Arnstedt, &c.	Avicula socialis, Terebratula vulgaris, Encrinites liliiformis.	(Wanting.)
			Lower, or Wellenkalk.			
		Bunter-Sandstein.	Upper. Lower.	Region around Thüringerwald and Harz, &c.	Trematosaurus, Odontosaurus, } Labyrinthodonts.	New Red or "Bunter" Sandstone of Chester, Liverpool, &c.
Rocks.	Permian.	Bunter-Schiefer.	Red sandstone, &c. Schist, with impure limestone.	Around the Thüringerwald, S. of the Harz, &c.	Calamites arenarius.	Red and green gypseous marls (Sedgwick). Yorkshire, Lancashire, and Nottinghamshire.
		Zechstein and Kupfer-Schiefer.	Rauchwacke, Gypsum, &c. Dolomite, Zechstein.	Around the Harz and Thüringerwald, and numerous tracts of Germany.	Productus horridus, Spirifer alatus, Strophalosia Morrisiana, Avicula speluncaria, &c.	Brecciated & compact limestones; Humbleton, Sunderland; cliffs from Hartlepool to Sunderland.
		Rothe-Todte-Liegende.	Bituminous and Copper Slate.	Mansfeld, Reichelsdorf, around the Harz and Thüringerwald.	*Fishes.* — Palæoniscus, Pygopterus, Platysomus, &c. *Reptiles.*—Protorosaurus (2 sp.).	Marl-slate; Sunderland and Hartlepool (Durham), Knaresborough to Mansfield.
			Grau- and Weiss-Liegende. Conglomerate, Red Sandstone, &c.	Around the Thüringerwald, Mansfeld, &c. Eisenach, Kyfhausen, Rotheburg, S. Harz, Halle near Dresden.	Walchia and many other Permian plants, near Zwickau. (Psaronites) Kyfhausen, S. of the Harz.	Pontefract Rock (Smith). Lower Red Sandstone, &c., of Cumberland, Lancashire, Nottinghamshire, Shropshire, Worcestershire, Staffordshire, &c.
	Carboniferous.	Stein-Kohlen.	Shale, Sandstone, and Coal.	Southern Harz, N. & S. Thuringia, Wettin, Ilmenau, Westphalian & Bohemian Coal tracts.	Characteristic fossil plants. Archegosaurus (2 sp.).	Coal-fields of Durham, S. Wales, Lancashire, &c.
		Floetzleerer Sandstein	Youngest Grauwacke	Zone around the Rhenish Provinces, south-west part of the Harz, Taunus, and Nauheim, Saarlem and Schleitz.	Fossil plants occasionally.	Millstone Grit of Yorkshire, Derbyshire, Lancashire, and South Wales. Culm Series of Devonshire. Coal-measures of a part of Scotland.
		Berg-kalk.	Posidonomya-schist. Platten-formige Kalk. Kiesel-Schiefer.	Herborn, Rhine, near Grund, Harz, Ratingen, Arnsberg, E. of Hof, Rhenish Provinces.	Posidonomya Becheri, Productus semireticulatus, and others. Amplexus coralloides, &c.	Mountain Limestone Series (Phillips), Culm Limestone of Devonshire, and Lower Limestones and Coal of Scotland.
	Devonian.	Upper Devonian.	Cypridinen-Schiefer, with peculiar land plants. (Kramenzel-Stein.)	Right bank of Rhine, Mecklinghausen, Laasphe, Selters, Weilburg, Saalfeld, and Saxony.	Cypridina serrato-striata, Clymeniæ. Plants of many new forms.	Petherwin and Barnstaple Limestone, Baggy Point Sandstone, Upper Old Red of Scotland.
			Flint-Schiefer.	Westphalia (Mestode, &c.).	Goniatites retrorsus.	Hard Slate and Schist of Morte Bay, N. Devon.
		Middle Devonian.	Eifel Limestone and Calceola-Schiefer.	Both banks of the Rhine, Eifel, Paffrath, Refrath, &c. Elbingerode, Harz, &c.	Stringocephalus Burtini, Megalodon cucullatus. Coccosteus and other fishes.	Combe Martin, Ilfracombe, North Devon. Plymouth and Babbicombe, Devonshire slates (Austen). Middle Old Red Sandstone and Cornstone. Caithness Flags, with fishes and plants.
		Lower Devonian.	Wissenbach Slates. Spirifer Sandstone and Slate. (Syst. Rhénan, Dumont.)	Wissenbach and Caub. Coblentz and bank of the Rhine, N.-Western Harz, &c.	Bactrites, Orthocerata, Goniatites. Spirifer macropterus, Pleurodictyum problematicum, Chonetes semiradiatus, Phacops laciniatus, &c.	N. Foreland and Porlock, North Devon, Torquay in S. Devon. Lower Old Red Sandstone, and Conglomerate of Scotland*.
Palæozoic.	Silurian.	Upper Silurian.	Limestones and Shales of Prague.	Prague; Eastern Harz.	Trilobites; 75 species of the genera Acidaspis, Calymene, Cheirurus, Cyphaspis, Harpes, and Phacops; Graptolites and many Cephalopoda in the lower beds.	Ludlow and Wenlock Rocks.
		Lower Silurian.	Schistose Slates, Grits, Quartzites.	Prague and Bohemia, South Thüringerwald, S. and W. of Saalfeld, Steinach, Schwartzburg, Schleitz, &c.	Graptolites of many species, mostly Diplograpsus; also Graptolithus Ludensis; Trilobites of the genera Trinucleus, Æglina, Asaphus, Illænus, Remopleurides, Agnostus, &c. Orthis, Leptæna, and other Brachiopods; Cystideæ, Nereites, &c.	Caradoc Sandstone and Llandeilo Rocks.
			"Primordial zone" of Barrande's Silurian Basin.	S. of Prague; South Thüringerwald?	Paradoxides, Conocephalus, Sao, Agnostus, Olenus; Orthis and Cystideæ. Fucoids.	Lingula Flags of N. Wales (Stiper Stones, Shropshire; W. flank of Snowdon).
		Base of the Silurians of Bohemia (Barrande).	Slaty and Quartzose Rocks (often green and purple).	S. of Prague and Southern Thüringerwald.	Fucoids the only fossils yet found in Germany.	Longmynd Rocks (Cambrian of the British Geological Surveyors).

* The *exact* relations which the Devonian divisions of the Continent of Europe and England bear to those of the *Old Red Series of Scotland* still require definition. It is, however, suggested, that the Upper Old Red of Scotland, as characterized by certain species of *Holoptychius* and *Glyptopomus*, is the Sandstone equivalent of the Upper Devonian,—*i. e.* of the "Cypridinen-schiefer" of Germany and the Petherwin or Clymenia Limestone of Devonshire. The bituminous and calcareous flagstones of Caithness, with their numerous ichthyolites and peculiar plants, both marine and terrestrial, represent, it is believed, the Eifelian or Middle Devonian passing down into the lower division; whilst the coarse breccias and conglomerates in the Sandstones which form the base of the vast Old Red Series of the north of Scotland probably occupy the horizon of the Lower Devonian or "Système Rhénan" of Dumont. Whether or not these suggested parallelisms be maintained, it is manifest to every one who has studied the great mineral masses of Scotland which are included in the term "Old Red Sandstone," that they constitute full equivalents *in time* of all the deposits to which in any region the name of "Devonian" has been applied.—R. I. M., Sept. 29, 1855.

phical direction of the masses of rock, from their normal alinement of N.E. & S.W. to one trending from N.W. to S.E.; the turbulence of the period being decisively characterized by great outbursts of porphyry and the extravasation of vast sheets of porphyritic lava.

It is, indeed, manifest from the convoluted and dislocated condition of the secondary strata, particularly those of the Muschelkalk, which lie between the Thüringerwald and the Harz, as well as from similar appearances extending even to the older tertiary rocks lying north of the Harz, or between that ridge and the line of ancient rocks near Magdeburg, that each of the elder or flanking masses was an habitual area of upheaval and oscillation, the upward and downward movements of which compressed the interjacent formations into the plicated forms which they still exhibit.

In reflecting upon the broad external features only which were successively impressed on the one tract and on the other, we infer, that, however the two regions were thrown into nearly parallel directions, there are in the Thüringerwald proofs of ancient movements of which we find no trace in the Harz. In this way we obtain evidence of the truly *local* character of all such disruptions, in addition to the examples previously cited by one of us, and to other cases mentioned by M. Barrande*.

In truth, whilst each of the tracts here spoken of present some marked analogies to the Silurian basin of Bohemia, each of them differs more from that tract than they do from one another. In their great fundamental rocks of greenish and talcose grauwacke, the South Thüringerwald and the district of Prague are alike, as well as in the chief mass of the Lower Silurian rocks, though the fossils of the primordial zone of Bohemia have not been found in the Thüringerwald, and all the Lower Silurian is wanting in the Harz.

Again, the rich Upper Silurian limestones of Bohemia have no true representatives in Thuringia,—the uppermost member only of that division having been detected in the Harz.

Still more striking is the distinction between the two tracts under consideration and the basin of Bohemia; for whilst the Harz contains all the members of the Devonian rocks, with a copious development of the Lower Carboniferous, and whilst the Thüringerwald differs from it in not possessing either the central or the lower Devonian bands, there are no evidences of the existence of these formations in Bohemia, where the Silurian rocks are at once and abruptly followed by the Upper Coal-fields.

We collate these data to show, that whilst there are breaks in the Silurian series of Britain,—*ex. gr.* in one part of S. Wales beneath the Wenlock Shale, and above the Upper Caradoc or May Hill sandstone, and in another below the latter rock,—that in the north of England the Devonian rocks consist of a mere conglomerate, and that even one part of the south-west coal field is known to be transgressive to another,—our country offers no example of that great fracture between the lower and upper divisions of the Carboniferous group which is so very dominant a physical feature throughout Germany and France.

* See Bull. Soc. Géol. France, vol. xi. p. 311, &c.

But, notwithstanding all these differences—whether consisting of such local dismemberments or varied lithological conditions, the four natural palæozoic groups of Russia, Scandinavia, Germany, and France have been perfectly assimilated, through their organic remains, to their congeners in Britain; so that, despite of great breaks in each natural division of these regions, the classification by Silurian, Devonian, Carboniferous, and Permian remains is everywhere maintained.

Lastly, let us recollect, that the very first step which the geologist takes in ascending from the palæozoic to the mesozoic formations must convince him, that great and general mutations of life upon the surface of the globe were not dependent on such disruptions as those to which we have alluded; for in Germany no physical dismemberment has been observed which separates the strata accumulated at the close of the Permian rocks from those formed in the earliest period of the Trias,—the summit of the one being everywhere conformable to the base of the other; and yet the change of life which took place at that period of quiet physical transition was absolute and complete.